DOCUMENT RESUME

ED 228 070 SE 041 267

TITLE	Changing Employment Patterns of Scientists, Engineers, and Technicians in Manufacturing Industries: 1977-80. Final Report.
INSTITUTION	National Science Foundation, Washington, D.C.
REPORT NO	NSF-82-331
PUB DATE	Oct 82
NOTE	65p.
AVAILABLE FROM	Single copies may be obtained gratis from the National Science Foundation, 1800 "G" St., NW, Washington, DC 20550.
PUB TYPE	Reports - Research/Technical (143) -- Statistical Data (110)
EDRS PRICE	MF01/PC03 Plus Postage.
DESCRIPTORS	Chemistry; Computer Science; *Employment Patterns; Employment Statistics; Engineering; *Engineers; *Manufacturing Industry; Occupational Surveys; *Paraprofessional Personnel; Sciences; *Scientists; *Technical Occupations; Technology

ABSTRACT

This report presents an analysis of science, engineering, and technician (SET) employment within manufacturing industries based on data from the 1977 and 1980 Occupational Employment Statistics survey. The purposes of the report are to: (1) summarize employment data for detailed SET occupations in manufacturing to describe demand patterns; (2) identify the fastest growing occupational and industrial demand sectors; and (3) assess the relative importance of changing industrial composition and staffing patterns as they determined variations in occupational demand within these industries between 1977 and 1980. Analysis of employment by occupation is provided in section 1, considering separately, scientists, (chemists, computer systems analysts, and other science occupations), engineers (electrical/electronic, mechanical, industrial engineers, and other engineering occupations), and technicians (engineering technicians, computer programmers, and science technicians). Employment by industry is considered in section 2, focusing on durable-goods industries, nondurable-goods industries, technological intensity and SET employment growth, and industrial detail of high-technology. An evaluation of the importance of staffing pattern changes in explaining the movement of SET employment within manufacturing industries is provided in section 3. Technical notes on the survey and detailed statistical tables are provided in appendices. (JN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☑ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

ED228070

changing employment patterns of scientists, engineers, and technicians in manufacturing industries: 1977-80

SE041267

national science foundation

final report

NSF 82-331

related publications

Science Resources Studies Highlights

	NSF No.	Price
S/E Personnel		
"Labor Market Slackens for New Science and Engineering Graduates"	82-330	-----
"Labor Markets for New Science and Engineering Graduates in Private Industry"	82-310	-----
"Manufacturing Industries With High Concentrations of Scientists and Engineers Lead in 1965-77 Employment Growth"	79-307	-----

Detailed Statistical Tables

	NSF No.	Price
S/E Personnel		
Scientists, Engineers, and Technicians in Private Industry:1980	81-329	-----
Employment of Scientists, Engineers, and Technicians in Manufacturing Industries: 1977	80-306	-----

Reports

	NSF No.	Price
S/E Personnel		
Scientists, Engineers, and Technicians in Private Industry, 1978-80	80-320	-----

Availability of Publications

Those publications marked with a price should be obtained directly from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Where no price is listed, single copies may be obtained gratis from the National Science Foundation, Washington, D.C. 20550.

(See inside back cover for Other Science Resources Publications.)

foreword

Science, engineering, and technician personnel are essential for the achievement of high levels of economic growth, technological advancement, and national security. In recognition of the vital role played by this resource and to gain a better understanding of the world around us, the National Science Foundation collects a wide variety of data on the employment, training, supply, and demographic characteristics of such personnel for use by Government, industry, educators, and the general public.

A major part of this data collection effort has been the development of detailed employment statistics for scientists, engineers, and technicians in private industry, a sector which employs 45 percent of our Nation's scientists and almost 80 percent of its engineers. In recent years, declining productivity and increased product competition from foreign countries have both served to focus attention on the strengthening of our industrial base.

Growth in the demand for science, engineering, and technician personnel by private industry in the face of potential shortfalls in supply is a continuing concern, especially in high demand fields such as computer science and engineering. An understanding of variations in the utilization of scientists, engineers, and technicians in response to shifts in industrial composition within the economy and staffing patterns within industries is essential. Such information provides a foundation for projecting future occupational requirements. These requirements, in turn, influence the decision processes of policymakers and employers in anticipating skill shortages and of educators and individuals in career planning.

This report presents the findings of an employment study based on data from the Occupational Employment Statistics surveys of the manufacturing sector conducted in 1977 and 1980. It provides comprehensive estimates of science, engineering, and technician employment by detailed occupational field and industry for 1980, the most recent year for which actual data are available. The report also represents the first application of these data for examining changes in the occupational demand for such personnel.

Charles E. Falk
Director, Division of Science Resources Studies
Directorate for Scientific, Technological, and International Affairs

October 1982

acknowledgments

This report reflects the joint efforts of the National Science Foundation's Division of Science Resources Studies and the Bureau of Labor Statistics' Division of Occupational and Administrative Statistics.

The analysis in this report was the responsibility of Jean E. Vanski, Program Analyst, Utilization Studies Group. Supervision, review, and guidance were provided by Joel L. Barries, Study Director, Utilization Studies Group; Alan Fechter, Head, Scientific and Technical Personnel Studies Section; and Charles E. Falk, Director, Division of Science Resources Studies. Bureau of Labor Statistics' staff members who supervised data collection and estimation and who provided the Foundation with timely and expert technical assistance were Thomas Shirk, Supervisory Economist, and Linda Hardy, Occupational Employment Statistics Supervisor.

contents

Page

Introduction vi

Highlights vii

Sections:

1. Employment by Occupation 1
   - Scientists 1
     - Chemists 1
     - Computer Systems Analysts 2
     - Other Science Occupations 3
   - Engineers 3
     - Electrical/Electronic Engineers 3
     - Mechanical Engineers 4
     - Industrial Engineers 4
     - Other Engineering Occupations 5
   - Technicians 5
     - Engineering Technicians 5
     - Computer Programmers 5
     - Science Technicians 6

2. Employment by Industry 7
   - Durable-Goods Industries 7
   - Nondurable-Goods Industries 8
   - Technological Intensity and SET Employment Growth 8
   - Industrial Detail of High-Technology Industries 9

3. Measuring Determinants of Occupational Change: Industry Growth and Staffing Patterns 11
   - Decomposing Changes in Occupational Employment 12
   - Results 12
   - Implications 14

Appendixes:

A. Technical Notes 17

B. Detailed Statistical Tables 21

introduction

A major policy concern is whether there will be an adequate supply of scientists, engineers, and technicians to meet growing demand in the years ahead. Shortages of skilled personnel, if they occur, will reduce economic growth and jeopardize America's position with respect to highly competitive foreign producers. As a basis for analyzing the future balance of supply and demand for skilled personnel, it is essential to monitor the level and character of science, engineering, and technician (SET) demand within major employment sectors: private industry, academia, and Government.

Private industry, which employs more than one-half of this country's science and engineering (S/E) work force, has been a focal point for analysis. A large part of private industry's demand for skilled personnel is concentrated within manufacturing industries. In 1980, these industries employed less than 30 percent of all workers in private industry, but provided jobs for 40 percent of the scientists, 60 percent of the engineers, and 45 percent of the S/E technicians.[1]

Manufacturing industries have been undergoing a process of adjustment which has increased their importance in determining future requirements for SET personnel. While failing to keep pace with the rapid employment growth experienced by service industries, the past decade has shown manufacturing establishments to be the dominant force behind the substantial employment gains made in engineering and technician occupations.[2] Evidence of the potential strength of this demand was apparent in employment data for the 3-year period analyzed in this report. Between 1977 and 1980, overall employment in these industries grew less than 3 percent. Despite this slow rate of growth, however, the numbers of scientists, engineers, and technicians each increased by roughly 20 percent.

The increasing concentration of these personnel within manufacturing industries is the result of changes in product mix which favor SET-intensive, high-technology industries, as well as changes in the staffing requirements of older, more mature industries. High-technology industries which manufacture computers, semiconductors, microprocessors, robots, and other state-of-the-art electronic equipment are expected to continue their rapid expansion in the years ahead, especially in light of the planned defense buildup. In addition to their role in the production process, scientists, engineers, and technicians are critical for the research and product development activities that are needed to ensure the competitiveness and growth of these industries.[3]

On the other hand, mature industries, such as those manufacturing steel and automotive products, are suffering the effects of falling output levels because of aging capital stock and declining growth in productivity. Despite declining employment levels, this report shows that the employment of scientists, engineers, and technicians in these industries has remained stable, or even increased, indicating a change in staffing patterns favoring these skilled personnel. These changes are, in part, the result of the continuing effort by industry and Government to increase the productivity, efficiency, and competitiveness of older industries through incorporation of major technological innovations in the production process.[4] As the economic climate improves and the rate of "reindustrialization" increases, the demand for SET personnel can be expected to increase.

This report presents an analysis of SET employment within manufacturing industries based on data from the 1977 and 1980 Occupational Employment Statistics (OES) survey. The purpose of the report is threefold: First, 1980 employment data are summarized for detailed SET occupations in manufacturing industries in order to describe demand patterns; second, employment changes are analyzed in order to identify the fastest growing occupational and industrial demand sectors; finally, the paper attempts to assess the relative importance of changing industrial composition and staffing patterns as they determined variations in occupational demand within these industries between 1977 and 1980.

[1] National Science Foundation, *Scientists, Engineers, and Technicians in Private Industry: 1980* (Detailed Statistical Tables) (NSF 81-329) (Washington, D.C., 1981) presents industry totals for SET employment. For national SET totals, see National Science Foundation, *U.S. Scientists and Engineers: 1980* (Detailed Statistical Tables) (NSF 82-314) (Washington, D.C., 1982).

[2] Carol Boyd Leon, "Occupational Winners and Losers: Who They Were During 1972-80," *Monthly Labor Review*, June 1982.

[3] Jerry Hagstrom, "High-Tech Leaders Have Their Own Ideas of What Government Can Do For Them," and Tim Miller, "The Coming Job Crunch," *National Journal*, No. 20, May 15, 1982.

[4] Nathaniel J. Mass and Peter M. Senge, "Reindustrialization: Aiming for the Right Targets," *Technology Review*, August/September, 1981.

highlights

- Manufacturing industries are a major determinant of the level of SET employment. In 1980, they provided jobs for 1,345,000 such workers who represented 40 percent of the Nation's scientists, 60 percent of its engineers, and 45 percent of S/E technicians.
- Between 1977 and 1980, employment in each of the three SET occupational categories grew by 20 percent despite slow growth in total industry employment. Strong growth in SET employment was generated by: (1) the relative employment gains of high-technology industries; (2) industry's emphasis to increase productivity, quality, and competitiveness; and, (3) the diffusion of computer technology.
- Over this period, changes in staffing patterns were more important than industry growth in determining the strength of SET employment demand within the sector. Changes in staffing behavior accounted for 85 percent of the growth in science employment, and slightly more than two-thirds of the employment growth in engineering and technician professions.
- The majority of SET employment growth was generated by high-technology industries. Industries with high concentrations of SET employment—machinery (except electrical), electrical machinery, chemicals, transportation equipment, and instruments—experienced average employment growth for science occupations, but significantly higher demand for engineering and technician personnel than reported in other manufacturing industries.
- In 1980, chemists and computer systems analysts constituted over three-quarters of the 145,000 science jobs in manufacturing industries. Jobs for chemists increased only slightly from 1977 to 1980. Employment of computer systems analysts increased by over 40 percent, however, constituting the bulk of the growth in science employment. By 1980, computer systems analysts showed every indication of overtaking chemists as the largest science occupation in these industries. Employment in life and other physical science occupations increased moderately during this time; mathematical sciences occupations underwent the only employment decline.
- In 1980, engineering employment in manufacturing industries was 606,000 with the majority of jobs concentrated in electrical/electronic, mechanical, and industrial engineering specialties. Growth in the number of industrial engineering jobs accounted for most of the increase in engineering employment making it the fastest growing SET occupation. According to professional societies, the strength of employment demand for this occupation resulted from industry's preoccupation with productivity, quality improvement, and cost competitiveness, as well as the applicability of these job skills to all industries.
- In 1980, there were about 594,000 S/E technicians employed in manufacturing industries. Two-thirds of these personnel were engineering support personnel; one-quarter was divided evenly between science technicians and computer programmers.
- Among manufacturing industries, durable-goods industries provided over three-quarters of SET jobs. These industries provided slightly less than one-half the science jobs, but four-fifths of the jobs for engineers and technicians. Within the durable-goods industries, most of the employment, as well as its growth, was concentrated in three industries: machinery (except electrical), electrical machinery, and transportation equipment.

section 1.

employment by occupation

The employment of scientists, engineers, and technicians in manufacturing industries increased by 20 percent between 1977 and 1980—from 1,122,000 to 1,345,000. Increases in employment were comparable for the major SET occupational categories, with the number of scientists in these industries increasing by 19 percent and the numbers of engineers and technicians each by 20 percent. The average annual growth rates in these occupations were 5.9 percent, 6.2 percent, and 6.3 percent, respectively. Growth in employment of these occupations comprised 44 percent of total employment growth in these industries.

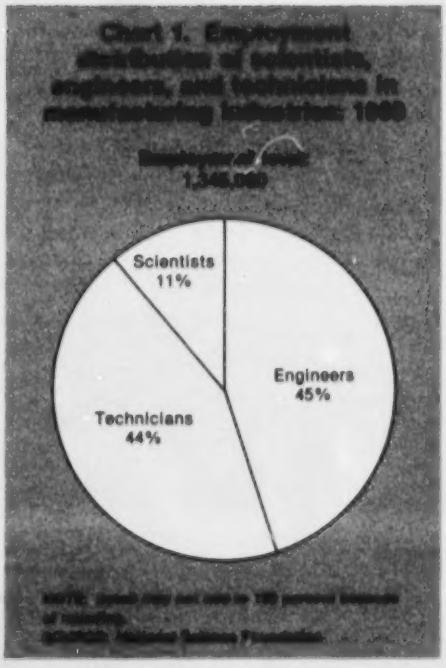
scientists

In manufacturing industries, job opportunities for both engineers and technicians outnumbered those for scientists by roughly 4 to 1. In 1980, 145,000 scientists were employed in these industries, amounting to two-fifths of all employed scientists in the United States.

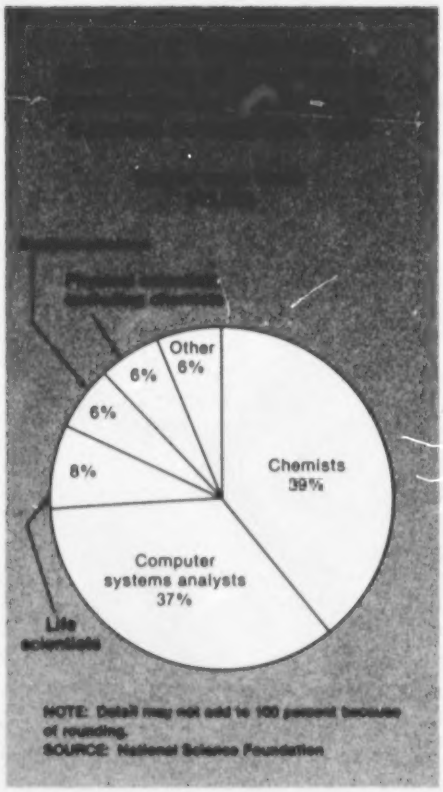
Jobs for scientists in manufacturing industries were concentrated in two occupations, with chemists and computer systems analysts representing three-quarters of the number of scientists employed in these industries (chart 1). Mathematical, life, and physical (excluding chemical) scientists made up, respectively, 5 percent, 8 percent, and 6 percent of science employment in these industries.

chemists

Traditionally, chemists have constituted the largest science occupation employed in manufacturing industries. In 1980, there were 57,000 chemists employed in these industries, comprising nearly two-fifths of its science employment (chart 2). In relation to the entire economy, this represented almost one-third of employment in chemical science occupations. The employment of chemists was concentrated in relatively few manufacturing industries. Nearly three-fifths of the job opportunities for this occupation were provided by chemical goods-producing industries; food and food products industries employed 11 percent of chemical scientists. The remaining chemists were scattered throughout the other industries (table 1).



Between 1977 and 1980, the employment of chemists grew by less than 5 percent, or about 1.5 percent per year (table 8). Demand for this occupation was moderate because of the concentration of chemists in nondurable manufacturing industries which underwent little employment growth.



Despite this low level of growth, manufacturing industries accounted for the majority of the employment increase of chemists during this period, primarily because of their importance in the development of new product lines and their input to the fields of energy, pollution control, and health care.[5] The involvement of industrial chemists in R&D activities within manufacturing industries and the general increase in R&D funds available to industries which were major employers of chemists also increased demand for these personnel.[6]

computer systems analysts

Individuals were classified as computer systems analysts if they performed jobs analyzing business, scientific, or technical problems in the application of electronic data processing systems. In 1980, 53,000 such personnel were employed in manufacturing industries. This represented almost two-fifths of total science employment in these industries and comprised almost one-fifth of the economy's total employment in this occupation.

More than 70 percent of computer systems analysts employed in manufacturing industries were in establishments producing durable goods. Major industrial employers in the durable-goods industries included: Machinery (except electrical), 22 percent; electrical machinery, 20 percent; and transportation equipment, 12 percent. The nondurable chemical-producing industry employed 11 percent of such personnel (table 2).

In the 3-year period between 1977 and 1980, the number of computer systems analysts increased by almost 32 percent, at an annual rate of about 9.7 percent (table 8). This growth rate was larger than that anticipated by occupational analysts and represented 65 percent of the increase in science employment within manufacturing industries.[7] The rapid rise in the employment of computer systems analysts resulted from the diffusion of computer technology in application to process and quality control, business forecasting, and management information functions. Utilization of such personnel was facilitated by the interaction of two factors: First, strong demand was generated by rapid economic and employment growth in durable-goods industries, which formed the core of demand for this occupation; second, as microprocessing has been applied across a broad spectrum of manufacturing functions, industrial staffing patterns have shifted to include more of these workers. Developing technologies, such as robotics and computer-assisted design and manufacturing (CAD/CAM), had already begun to increase demand for computer systems analysts in the late seventies. Employment growth in this occupation was facilitated by the interdisciplinary supply of workers who were able to meet necessary job qualifications. Employers have been able to fill positions for computer systems analysts with individuals trained in other S/E disciplines. For example, of the 21,000 computer scientists in 1980 who had received bachelor's and master's degrees in S/E fields two years earlier, only 40 percent had majored in computer science; among the remaining, 22 percent had majored in mathematics, 11 percent in engineering, and 9 percent in social sciences.[8] Despite this flexibility, by 1981 industry was beginning to report shortages of such

Table 1—Chemists by major industry of employment: 1980

Industry	Thousands	Percent[1]
Total, all industries	57	100
Major industries	44	78
Chemical	33	58
Food and food products	6	11
Rubber and plastic products	3	5
Primary metals	2	4
Other industries	13	22

[1]Percentages may not correspond to employment levels because of rounding.

SOURCES: Bureau of Labor Statistics and National Science Foundation

Table 2—Computer systems analysts by major industry of employment: 1980

Industry	Thousands	Percent[1]
Total, all industries	53	100
Major industries	34	65
Machinery, except electrical	11	22
Electrical machinery	10	20
Transportation equipment	6	12
Chemicals	6	11
Other industries	19	35

[1]Percentages may not correspond to employment levels because of rounding.

SOURCES: Bureau of Labor Statistics and National Science Foundation

[5]Department of Labor, *Occupational Outlook Handbook, 1982-83 Edition* (Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, April 1982).

[6]National Science Foundation, *Research and Development in Industry: 1979* (Final Report) (NSF 82-304) (Washington, D.C., 1981).

[7]The largest employment growth in the SET labor force is occurring in computer-related occupations. Their impact is discussed more thoroughly in Department of Labor, *Employment Trends in Computer Occupations*, Bulletin 2101 (Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, October 1981) and Max L. Carey, "Occupational Employment Growth Through 1990," *Monthly Labor Review*, August 1981.

[8]National Science Foundation, *Characteristics of Recent Science/Engineering Graduates: 1980* (Detailed Statistical Tables) (NSF 82-313) (Washington, D.C., 1982).

personnel.[9] To the extent that such shortages existed, reported employment growth in this occupation would have understated actual demand.

other science occupations

Only one-quarter of the scientists employed in manufacturing industries worked in occupations other than chemistry and computer systems analysis. The two largest occupational categories of those remaining were life and mathematical scientists.

Life scientists numbered 11,000 in 1980, representing less than 8 percent of science employment in manufacturing industries. Comprised predominately of biological and medical scientists, life scientists were concentrated almost exclusively in chemical and food processing industries. The data indicate some upward movement in the employment of these scientists between 1977 and 1980. This increase was more than likely in response to the growing interest in medical research and environmental issues.

Mathematical scientists numbered almost 8,000 in 1980. Roughly two-thirds were employed in durable-goods manufacturing, primarily in transportation equipment (aerospace), and electrical machine producing industries; most of the remaining one-third of these scientists were employed in nondurable industries producing chemical and printed products. Employment in this occupation declined within manufacturing industries between 1977 and 1980 (table 8). While employment opportunities were limited in mathematical occupations, this decline should not be interpreted as a reduction in demand for individuals with such skills. Mathematics has a broad range of applications and is a necessary skill for other occupations including computer systems analysis, programming, market research, etc. This is clearly seen by analyzing data on 1978 bachelor's- and master's-degree recipients who were in the labor market in 1980. Of the 12,700 individuals who received bachelor's and master's degrees in mathematical science, only 17 percent were employed as mathematicians or statisticians in 1980 while 36 percent were employed in computer science and 7 percent were classified as engineers.[10]

engineers

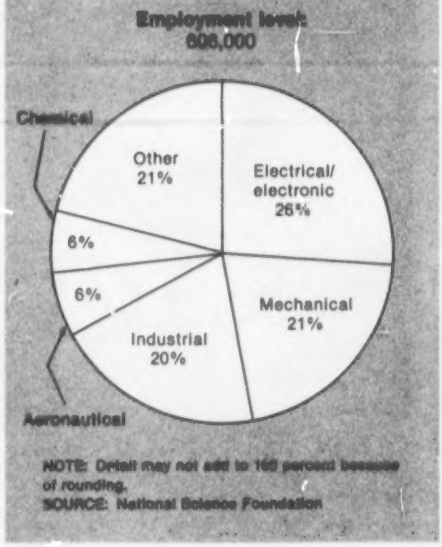
Private industry places more emphasis on the adaptation of technologies to production processes than to more basic types of research. Thus, engineers, who are concerned with the development of machines, instruments, materials, processes, and services, are more highly utilized by industry than scientists. Within private industry, manufacturing establishments generated almost 60 percent of the demand for such personnel in 1980. Economywide, manufacturing industries represent virtually half of engineering demand.[11]

Sixty-eight percent of the 606,000 engineers employed in manufacturing industries were concentrated in three occupations: Electrical/electronic engineers, 26 percent; mechanical engineers, 21 percent; and industrial engineers, 20 percent (chart 3). Of the remaining occupations, chemical and aeronautical engineers each comprised roughly 6 percent of employed engineers, while civil, metallurgical, petroleum, and safety engineers combined represented slightly over 3 percent.

electrical/electronic engineers

In 1980, there were 160,000 electrical/electronic engineers employed in manufacturing industries, representing roughly 26 percent of total engineering employment in these industries. Economywide, these industries generate jobs for more than three-fifths of individuals employed in these specialties.

Chart 3. Employment distribution of engineers in manufacturing industries by detailed occupation: 1980



NOTE: Detail may not add to 100 percent because of rounding.
SOURCE: National Science Foundation

Electrical/electronic engineering employment was concentrated in four industries. Almost 95 percent were employed in industries producing: Electrical machinery, 52 percent; machinery (except electrical), 21 percent; instruments, 12 percent; and transportation equipment, 9 percent (table 3).

Table 3—Electrical/electronic engineers by major industry of employment: 1980

Industry	Thousands	Percent[1]
Total, all industries	160	100
Major industries	150	94
Electrical machinery	83	52
Machinery, except electrical	34	21
Instruments	19	12
Transportation equipment	14	9
Other industries	10	6

[1]Percentages may not correspond to employment levels because of rounding.

SOURCES: Bureau of Labor Statistics and National Science Foundation

[9]National Science Foundation, "Labor Markets for New Science and Engineering Graduates in Private Industry," *Science Resources Studies Highlights* (NSF 82-310) (Washington, D.C., June 9, 1982).

[10]National Science Foundation, *U. S. Scientists and Engineers: 1980, op. cit.*

[11]Nineteen percent of engineers were designated as "other." This category would include occupational specialties not identified with those included on OES survey forms. Also, occupational detail on OES questionnaires differs by industry. If an occupation's employment level within an industry was considered, *a priori*, to be insignificant, it was omitted from the questionnaire. In such cases, engineers in these specialties would be included in the "other" category. To the extent this happened, employment levels in reported engineering specialties would have been understated. It is impossible to determine the relative importance of these two effects.

Between 1977 and 1980, the employment of electrical/electronic engineers increased by almost 13 percent, at a compounded annual rate of 4.2 percent (table 8). In recent years, it has been speculated that demand exceeds supply in this occupation.[12] Shortages, or unmet demand, would result in an understatement in growth rates. These occupations accounted for almost one-fifth of manufacturing industries' increase in engineering employment over the period. The strength of demand was the result of product development and applications in microelectronics, telecommunications, office automation, and robotics.[13]

mechanical engineers

In 1980, there were 127,000 mechanical engineers employed in manufacturing industries representing slightly over one-fifth of the engineering work force. These industries were the major source of demand for this occupation, constituting almost two-thirds of private industry's demand and roughly 54 percent of that economywide.

Mechanical engineers were employed across a broader spectrum of manufacturing industries than electrical/electronic engineers. Nonetheless, over 80 percent were concentrated in capital-intensive durable-goods industries. Five industries accounted for three-quarters of the employment of these engineers: Machinery (except electrical), 29 percent; transportation equipment, 15 percent; electrical machinery, 15 percent; fabricated metal products, 7 percent; and chemical goods, 7 percent (table 4).

Mechanical engineering employment increased by 13 percent between 1977 and 1980, growing at an annual rate of nearly 4.2 percent (table 8). The increase in employment in this specialty accounted for 15 percent of total engineering growth in the industries during this period. Increased utilization resulted from growth in the demand for, and rapid technological innovation in, industrial machinery and machine tools industries, as well as the increased concern for developing alternative energy systems.

[12]National Science Foundation, "Labor Markets for New Science and Engineering Graduates in Private Industry," *op. cit.*

[13]Richard W. Riche, "Impact of New Electronic Technology," *Monthly Labor Review*, Vol. 105, No. 3, March 1982.

Table 4—Mechanical engineers by major industry of employment: 1980

Industry	Thousands	Percent[1]
Total, all industries	127	100
Major industries	95	75
Machinery, except electrical	37	29
Transportation equipment	20	15
Electrical machinery	19	15
Fabricated metal products	12	9
Chemicals	9	7
Other industries	31	25

[1]Percentages may not correspond to employment levels because of rounding.

SOURCES: Bureau of Labor Statistics and National Science Foundation

industrial engineers

In 1980, there were over 123,000 individuals employed as industrial engineers in manufacturing industries, representing nearly one-fifth of total engineering employment in these industries.

Industrial engineering employment was concentrated within durable-goods producing industries. Four industries provided jobs for almost three-quarters of these workers: Machinery (except electrical), 26 percent; electrical machinery, 23 percent; transportation equipment, 18 percent; and fabricated metal products, 7 percent (table 5). Although concentrated in a few industries, the skills of these engineers were applicable across a broad spectrum of employers. Industries that traditionally employ few engineers, especially those producing nondurable goods (apparel, textiles, leather products, and printing), showed this occupation as their major engineering specialty.

Table 5—Industrial engineers by major industry of employment: 1980

Industry	Thousands	Percent[1]
Total, all industries	123	100
Major industries	91	74
Machinery, except electrical	32	26
Electrical machinery	28	23
Transportation equipment	22	18
Fabricated metals	8	7
Other industries	33	26

[1]Percentages may not correspond to employment levels because of rounding.

SOURCES: Bureau of Labor Statistics and National Science Foundation

Between 1977 and 1980, the data indicated an increase of over 60,000 industrial engineers, representing a 95-percent increase over the employment level reported in 1977 (table 8).[14] By definition, industrial engineers deal primarily with the efficient integration and utilization of major factors of production: people, machines, and materials. Industry's increasing concern over productivity growth, cost reduction, and quality improvement has led to the rapid diversification of job functions classified, as well as the strength of employment demand within this occupation. These functions range from operations research, motion-time analysis, value analysis, and personnel training, to the development and design of data processing and management systems to monitor quality, inventory, product distribution, and financial planning.

Employment growth in industrial engineering, similar to that in computer systems analysis, was facilitated by the flexible supply of personnel from other disciplines who could perform these job functions. New industrial engineering graduates numbered roughly 3,500 per year in the late seventies, accounting for less than one-fifth of increased manufacturing industrial requirements during the period covered by the analysis. Thus, a large part of the additional jobs in this occupation had to be staffed through reassignments or up-

[14]Rapid growth in industrial engineering employment was analyzed to determine whether it was being generated by OES survey procedures. No definitional change occurred in the two survey years that could have generated "apparent" as opposed to actual occupational growth. Microdata files were examined to determine if response bias resulted from variations in response rates by industry, size-class, or geographic region in either survey year. No such differences were found. Three industries were responsible for three-quarters of the growth in this occupation: Machinery (except electrical); electrical machinery; and transportation equipment. Analysis of the microdata files indicated that increased demand in each industry, was supported by an increasing utilization of these engineers across all size-classes of establishments. Representatives of the American Association of Engineering Societies, the American Institute of Industrial Engineers, and the American Society of Mechanical Engineers all attested to increasing demand in this occupation.

grading from other SET occupations and through recruitment of immigrants.[15]

other engineering occupations

In 1980, the remaining engineering specialties (aeronautical, chemical, metallurgical, civil, safety, petroleum, and other) combined to make up less than one-third of the engineering work force in manufacturing industries. Of these, aeronautical and chemical occupations dominated, with each representing roughly 6 percent of engineering jobs in manufacturing industries.

The 34,000 aeronautical engineers, employed in the production of transportation equipment (aircraft, missiles, and space vehicles) within manufacturing industries represented 95 percent of total employment in this occupation economywide.[16] There was virtually no employment growth reported for this field within manufacturing industries between 1977 and 1980. The lack of growth primarily resulted from declining production in commercial aircraft.

In 1980, the 34,000 chemical engineers employed in manufacturing industries represented nearly half of national employment in the occupation and almost two-thirds of all such workers in private industry. The majority of these engineers were concentrated in nondurable manufacturing industries engaged in the production of chemical and petroleum goods. Between 1977 and 1980, the growth in employment in chemical engineering specialties was 9.6 percent, yielding an annual growth rate of 3.1 percent. This growth was generated by an increase in the utilization of such personnel in three major industry groups: chemical goods, rubber and plastic products, and electrical machinery.

[15]Between 1977 and 1980, there were nearly 2,000 alien industrial engineers certified for admission to the United States. See Department of Labor, unpublished data.

[16]Reported employment of aeronautical engineers in 1980 was 26,700, a 24-percent decline over 1977. This estimate resulted from an undercount generated by the designation of aeronautical engineers in guided missile and space establishments as "other" engineers. The employment level reported in the text was estimated by assuming that the relationship between total employment in the occupation and that reported in establishments producing aircraft and parts was constant in the two survey years. The employment growth that resulted was more reasonable but less than the 7-percent growth reported for S/E employment in aerospace industries. See Aerospace Industries Association, Inc., "Aerospace Employment Continues Upward Trend," *Aerospace News*, October 22, 1981.

technicians

S/E technicians are essential to the functioning of manufacturing industries. These personnel provide support to various categories of S/E occupations through practical applications of theoretical knowledge and assistance in R&D activities. In 1980, manufacturing industries employed over 594,000 S/E technicians, representing 45 percent of total demand for these personnel by private industry. Almost two-thirds of the technicians were employed in engineering specialties, one-quarter were evenly distributed between employment in the fields of science technology and computer programming (chart 4).

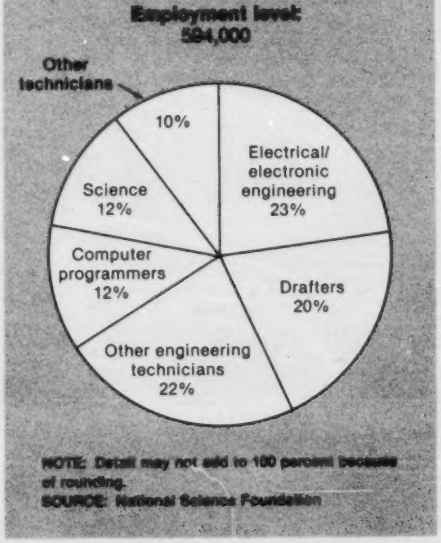
engineering technicians

In 1980, manufacturing industries employed 389,000 technicians as engineering support personnel. The two major technician specialties were in electrical/electronic engineering and drafting. With employment levels of 136,000 and 120,000, respectively, each accounted for roughly one-third of the jobs for engineering technologists. Of the remaining occupational subspecialties in this category, mechanical technicians accounted for 9 percent of employment; industrial technicians, 5 percent; and tool programmers, almost 4 percent.

Similar to general engineering employment, engineering technicians were almost exclusively employed in durable-goods manufacturing industries. Over three-quarters of their employment was concentrated in four industries: Electrical machinery, 28 percent; machinery (except electrical), 25 percent; transportation equipment, 14 percent; and instruments, 9 percent (table 6).

Between 1977 and 1980, the employment of engineering technicians increased by 17.6 percent, at a compounded annual rate of 5.5 percent. Over the 3-year period, electrical/electronic technicians showed the most rapid increase, 27.7 percent, paralleling the strong demand for highly trained electrical/electronic engineers. Other technician engineering occupations, combined, grew at a more modest rate of 12.8 percent (table 8). Growth in the demand for engineering technicians resulted from a variety of factors including industry expansion; changes in the staffing pattern of S/E personnel; and the automation of industrial processes. Growth in the employment of technicians also resulted from the development of new specialties, such as industrial engineering technicians and tool programmers.

Chart 4. Employment distribution of technicians in manufacturing industries by detailed occupation: 1980



NOTE: Detail may not add to 100 percent because of rounding.
SOURCE: National Science Foundation

computer programmers

In 1980, there were 73,000 computer programmers employed in manufactur-

Table 6—Engineering technicians by major industry of employment: 1980

Industry	Thousands	Percent[1]
Total, all industries	389	100
Major industries	298	76
Electrical machinery	107	28
Machinery, except electrical	98	25
Transportation equipment	55	14
Instruments	36	9
Other industries	92	24

[1]Percentages may not correspond to employment levels because of rounding.

SOURCES: Bureau of Labor Statistics and National Science Foundation

ing industries, accounting for 12 percent of technician employment. Computer programmers, as computer systems analysts, perform job functions related to business, as well as to scientific and technical problems in the application of electronic data-processing systems. These data do not differentiate between such functions.

Manufacturing industries employ fewer than one-third of all computer programmers within private industry. Within these industries, however, three-quarters of the employment of these personnel are contained in five industries: Machinery (except electrical), 39 percent; electrical machinery, 18 percent; transportation equipment, 8 percent; printing and publishing, 6 percent; and chemicals, 6 percent (table 7).

Computer programming was second only to industrial engineers as the fastest growing SET occupation in manufacturing industries. Between 1977 and 1980, employment of computer programmers increased by over 45 percent, at an average annual rate of 13.2 percent (table 8). This increase was achieved in part through expansion of industries which were major employers of such personnel. The greatest contributions to growth in this occupation, however, were from the diffusion of computer technology and its application to industrial processes, as well as the flexible supply of personnel who were able to perform the job requirements of this occupation.

Table 7—Computer programmers by major industry of employment: 1980

Industry	Thousands	Percent[1]
Total, all industries	73	100
Major industries	55	77
Machinery, except electrical	28	39
Electrical machinery	13	18
Transportation equipment	6	8
Printing and publishing	4	6
Chemicals	4	6
Other industries	18	23

[1]Percentages may not correspond to employment levels because of rounding.

SOURCES: Bureau of Labor Statistics and National Science Foundation

Table 8—Employment growth of major science, engineering, and technician occupations in manufacturing industries

[In thousands]

Occupation	Employment		Percent Change[2]
	1977	1980[1]	
Scientists	122	145	19
Chemists	54	57	5
Computer systems analysts	40	53	32
Life[3,4]	9	11	22
Mathematical[4]	9	8	-17
Other[4]	12	17	44
Engineers	506	606	20
Electrical/electronic	142	160	13
Mechanical	112	127	13
Industrial	63	123	95
Other	189	196	4
Technicians	494	594	20
Electrical/electronic	106	136	28
Engineering, except electrical/electronic	224	253	13
Computer programmers	50	73	45
Science	61	71	18
Other	53	61	16

[1]Data for 1980 are presented in appendix B, tables B-2, B-6, and B-10; 1977 data were reported in National Science Foundation, *Employment of Scientists, Engineers, and Technicians in Manufacturing Industries: 1977* (Detailed Statistical Tables) (NSF 80-306).

[2]Percentages may not correspond to employment levels because of rounding.

[3]Includes agricultural, biological, and medical subspecialties only.

[4]Percent change indicates general employment trend. Computed on a small base, the change is not significantly different from zero.

SOURCES: Bureau of Labor Statistics and National Science Foundation

science technicians

In 1980, over 71,000 science technicians were employed in manufacturing industries providing support to the full range of science occupations. These technicians constituted approximately 12 percent of technician employment.

Reflecting the pattern of science employment, the employment of science technicians was concentrated in nondurable-goods industries producing chemicals, food and food products, textiles, and primary metals.

Growth in the number of jobs for science technicians paralleled that of scientists within manufacturing industries. Between 1977 and 1980, there was a 17.8-percent growth in the employment of science technicians, representing an averge annual growth rate of 5.6 percent.

section 2.

employment by industry

In the latter part of the seventies, there was an economic downturn in manufacturing industries. Thirteen of its 20 industries reported declining employment: Those that produced lumber, furniture, stone, clay, and glass products were feeling the results of declining construction activities; other industries like transportation, fabricated metals, and rubber products fell prey to declining domestic car production; and still others like apparel, textiles, leather, and petroleum products were succumbing to rising prices and falling consumer demand.[17] Strong employment growth in these industries was confined to several high-technology, high-productivity durable-goods industries that produced machinery (except electrical), electrical machinery, and precision instruments, as well as nondurable-goods industries whose activities included printing and publishing and the production of chemical goods. In the face of this relatively poor economic environment, the 20-percent increase in SET personnel which occurred between 1977 and 1980 provides some insight into the increasing role technological employment will play in the years ahead. Despite declining total employment in a majority of its industries, S/E personnel increased at an average annual rate of 6.1 percent, reversing the 1 percent average annual decline in the early- to midseventies.[18]

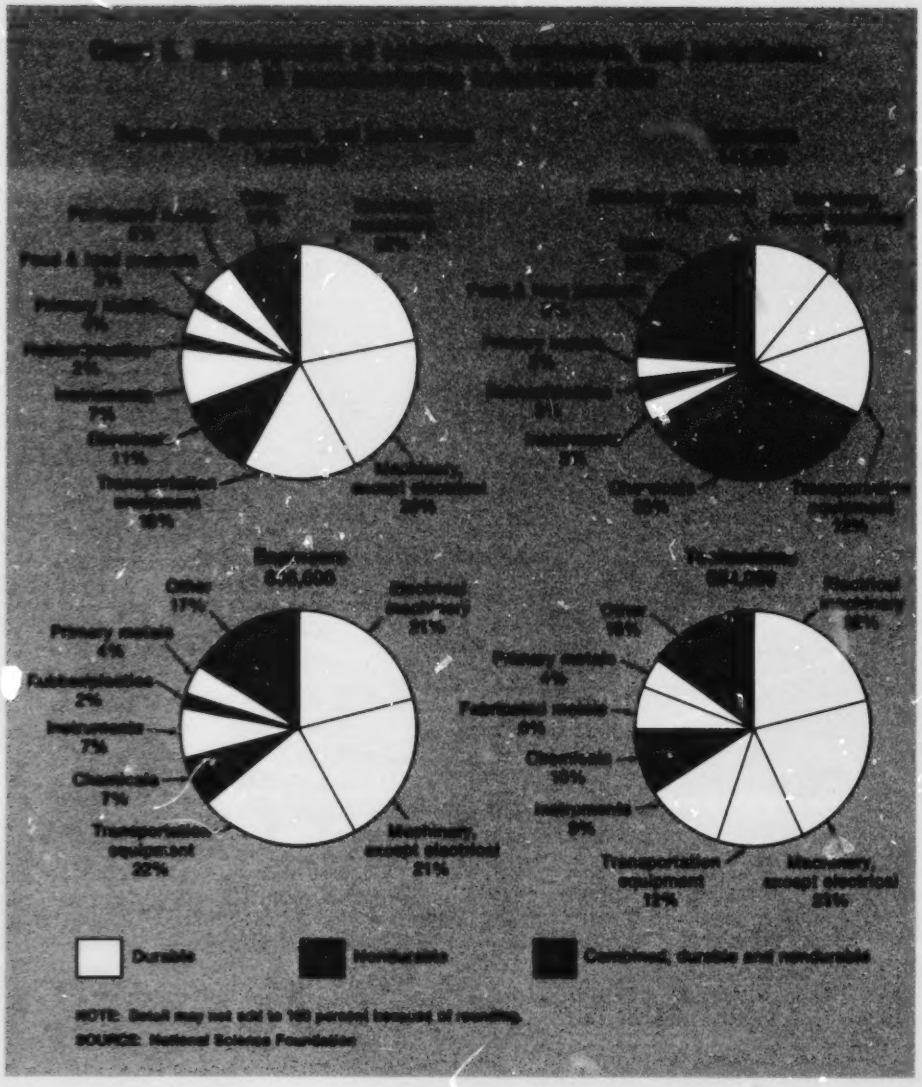
durable-goods industries

Durable-goods industries employed 1,050,000 scientists, engineers, and technicians in 1980, almost four-fifths of all SET personnel employed in manufacturing industries. Major employers in the industry group were electrical machinery; machinery (except electrical); and transportation equipment (chart 5).

Eighty-five percent of all manufacturing engineers were employed in durable-goods industries, including virtually all aeronautical, metallurgical, and electrical/electronic engineering personnel and over four-fifths of industrial and mechanical engineers. Roughly 79 percent of the technicians in manufacturing industries were employed in producing durable goods, including over 90 percent of technicians with engineering and 79 percent with computer programming specialties. Of the three major SET occupations, scientists were least concentrated in these industries. The 45 percent of manufacturing industries' scientists employed in durable-goods production, however, included most computer systems analysts, mathematicians, and social scientists. Durable-goods industries accounted for virtually all the increase in SET employment from 1977 to 1980. The 22-percent increase in SET employment in these industries was primarily generated by the strong performance of high-technology industries such as electrical machinery; machinery (except electrical); transportation equipment; and instruments.

[17] Department of Commerce, *1982 U.S. Industrial Outlook* (Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, January 1982).

[18] National Science Foundation, *Scientists, Engineers, and Technicians in Private Industry: 1978-80* (Special Report) (NSF 80-320) (Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, October 1980).



nondurable-goods industries

Nondurable-goods industries employed 296,000 scientists, engineers, and technicians in 1980, slightly over one-fifth of all SET personnel employed in manufacturing industries. The chemical products industry was clearly the dominant employer accounting for over half the SET employment.

Nondurable-goods industries employed 55 percent of all scientists in manufacturing industries. These industries were major employers of chemists and life scientists, occupations that are essential to chemical and food product industries. Only 15 percent of manufacturing engineers were employed by these industries.

Nondurable-goods industries, however, were the primary employers of chemical, petroleum, and safety engineers. With respect to technicians, nondurable-goods industries employed about one-fifth of all those working in manufacturing industries, including three-quarters of all science technicians.

Nondurable-goods industries showed very little overall employment gain between 1977 and 1980. In fact, many of these industries had declining levels of employment. Poor overall economic performance in these industries moderated SET employment growth to a rate below that of durable-goods industries. Nonetheless, growth in SET employment was still substantial compared to past trends. The number of SET personnel increased by 14 percent over the 3-year period in contrast to the 8-percent decline from 1970 to 1975.[19] The growth that did occur was spread evenly across food, paper, printing, and chemical industries.

technological intensity and SET employment growth

Employment of scientists, engineers, and technicians was concentrated in relatively few manufacturing industries. Five industries formed the core of demand for these occupations: Electrical machinery; machinery (except electrical); transportation equipment; chemicals; and instruments. These industries employed 71 percent of all manufacturing scientists; 81 percent of the engineers; and 75 percent of technicians (table 9).

The concentration of scientists, engineers, and technicians in a relatively small number of industries can result either from the scale of industrial production in these industries, or from the fact that their technology requires the staffing of a relatively large number of employees with SET skills. One way to determine the relative effect of these two determinants on the industrial distribution of SET personnel entails development of a "concentration ratio" for each industry, relating that industry's share of scientists, engineers, and technicians to its share of total industry employment.[20] A ratio close to unity for major industrial employers of SET personnel implies that the SET employment levels result primarily from the scale of industrial activity as reflected by total employment. A ratio greater than unity implies that the labor

[19] National Science Foundation, *Science and Engineering Employment: 1970-80* (Special Report) (NSF 81-310) (Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1981).

[20] The "concentration ratios" are defined as:

$$C_j = (S_j/S) / (E_j/E),$$

where C_j is the concentration ratio for industry j; S_j is the number of scientists, engineers, or technicians in industry j; S is the total number of scientists, engineers, or technicians in manufacturing industries; E_j is total employment in industry j; and E is total manufacturing employment. These ratios across all industries are presented in appendix B, table B-14.

Table 9—Science, engineering, and technician employment by technological intensity of manufacturing industry

Industry	Scientists				Engineers				Technicians			
	Concentration ratio 1980	Employment 1980[1]		Employment growth 1977-80	Concentration ratio 1980	Employment 1980[1]		Employment growth 1977-80	Concentration ratio 1980	Employment 1980[1]		Employment growth 1977-80
		Level	Percent			Level	Percent			Level	Percent	
All industries	1.0	145	100	18.7%	1.0	606	100	19.8%	1.0	594	100	20.2%
Technologically intensive industries	1.7	103	71	19.0	2.0	491	81	21.0	2.2	448	75	22.3
Electrical machinery	1.1	16	11	52.3	2.5	153	25	30.0	2.1	130	22	26.7
Instruments	1.1	5	4	17.7	1.9	40	7	17.6	2.5	53	9	45.0
Chemicals	6.4	51	36	1.9	1.2	42	7	11.0	1.8	59	10	7.9
Transportation equipment	1.3	17	12	54.3	2.4	132	22	18.7	1.3	72	12	26.9
Machinery, except electrical	.7	13	9	31.9	1.7	125	20	30.2	1.8	134	23	15.9
Other industries	.7	42	29	18.0	.5	115	19	14.9	.7	146	25	14.3

[1]Levels reported in thousands; numbers may not add to totals because of rounding.

SOURCE: National Science Foundation

forces of these industries are relatively intensive technologically.

For scientists, the most technologically intensive industry was chemical products, which employed over six times the number of scientists as would have been expected given the industry's share of total manufacturing employment. For engineering occupations, all five industries, except chemical products, had concentration ratios significantly greater than one. Electrical machinery and transportation equipment indicated the highest degrees of technological intensity with ratios of roughly 2.5. All five industries showed high concentrations of technicians, with precision instruments showing the greatest technological intensity, 2.5.

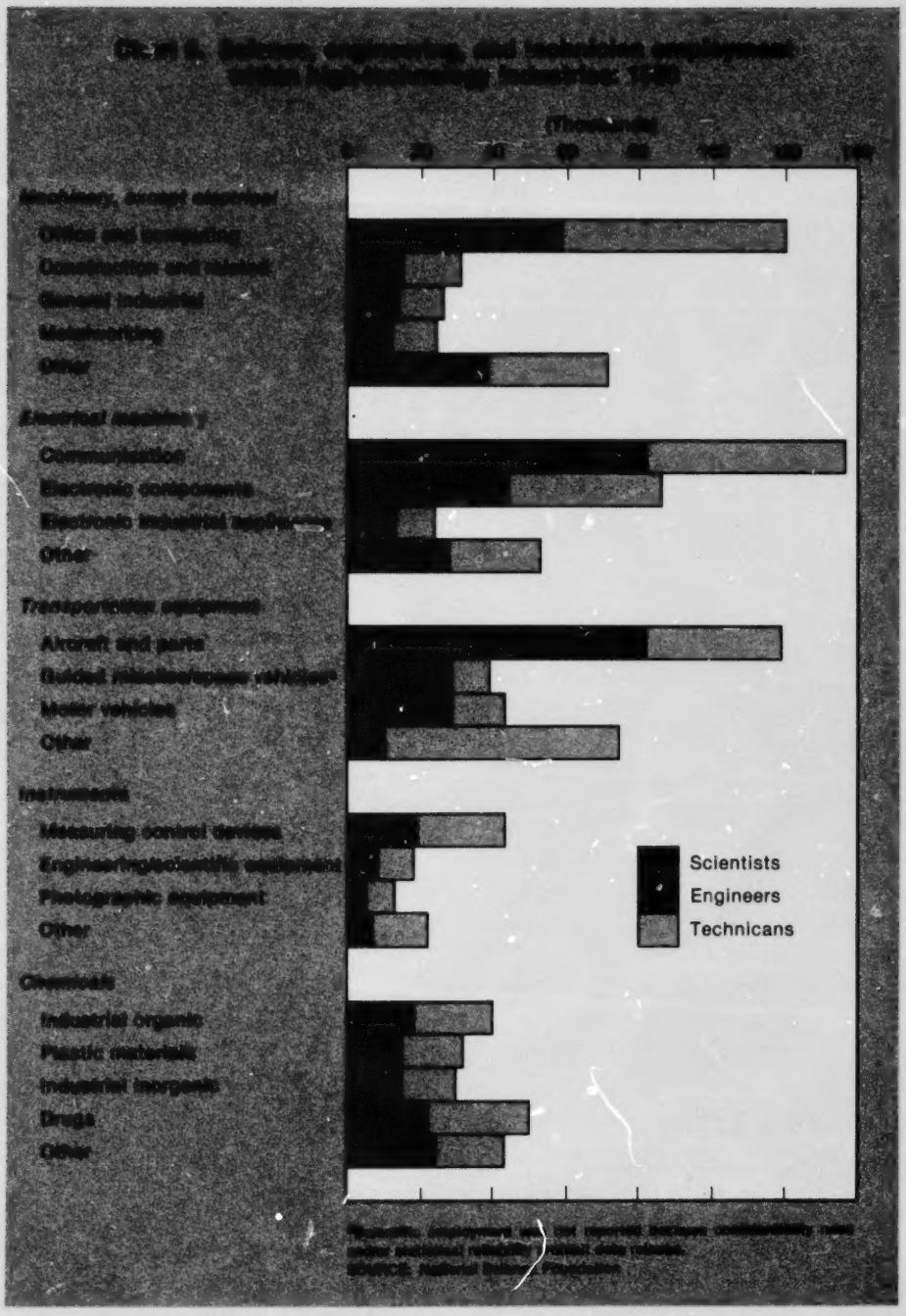
With the exception of the chemical industry, SET occupations in all technologically intensive industries grew rapidly between 1977 and 1980. For scientists, there was basically no difference in SET employment growth rates between technologically intensive and other industries. Much of the growth that did occur in these occupations resulted from increased utilization of computer systems analysts whose employment was widely diffused throughout manufacturing industries. For engineers and technicians, however, technologically intensive industries grew at 1.5 times the rate of all other industries. High growth rates in industries that favored the staffing of SET personnel helped explain the rapid employment growth for such personnel over the period. Strong performance in these industries provides some indication of the potential strength in demand for such fields.

industrial detail of high-technology industries

The concentration and employment growth of SET personnel in the high-technology industries mentioned previously make them important industries for analysis. With respect to current requirements, these industries are on the forefront of technological change and are primary spending targets for the current defense buildup. Each 2-digit industry presented in this analysis is composed of finer detailed 3-digit industries which vary with respect to production activity, technology, and, hence, employment levels, and staffing patterns.

Within the 2-digit machinery (except electrical) industry, the 3-digit industry producing office and computing equipment showed the highest utilization of SET personnel (chart 6). This detailed industry employed 54 percent of the 2-digit industry's science work force; 41 percent of the engineering work force; and 46 percent of that for technicians. Typical of all industries producing durable manufacturing goods, almost all scientists within the office and computing equipment industry were computer systems analysts. Almost three-quarters of the engineers were employed in electrical/electronic specialties, including one-third of the machinery industry's engineers and 13 percent of the mechanical engineering work force. Technician occupations dominated SET employment. Employment growth in this industry slowed somewhat in the late seventies, but there was no decline as evidenced in other industries comprising the major 2-digit category.

The 2-digit electrical machinery industry was dominated by the 3-digit industry producing communication equipment and electronic components. Firms producing these products accounted for three-quarters of the industry's employment in each of the three major SET categories. Engineering specialties dominated SET staffing in this 3-digit industry which employed three-quarters of electrical/electronic engineers in the electrical machinery industry; 64 percent of industrial engineers; and 59 percent of those in mechanical specialties. Employment growth in this detailed industry began to slow toward the end of the decade. By 1980, the 3-digit communications and electronic components industry was the only



category within the electrical machinery industry that did not undergo absolute reduction in employment levels.

The 3-digit industry producing aircraft and parts dominated SET employment in the 2-digit transportation industry. Two-thirds of the latter industry's scientists, over half the industry's engineers, and 46 percent of its technicians were employed in the production of aircraft and parts, primarily in computer and physical science specialties. Among engineering specialties, aircraft and parts establishments employed over three-fifths of the transportation industry's electrical engineering work force, and about half of both industrial and mechanical engineering specialties. Along with the 3-digit industry producing guided missiles and space vehicles, the aircraft and parts industry was the only one in the larger 2-digit category showing employment growth.

The 2-digit instruments industry was dominated by the 3-digit industry producing measuring and control devices. The measuring and control device industry employed only a third of both S/E personnel in the larger industry and over two-fifths of the technician work force. Although total employment in this detailed industry had begun to level off, employment was still making significant gains until 1980.

SET personnel within the chemical goods industry were fairly evenly employed across the component 3-digit industries. Staffing showed relatively equal utilization of S/E occupations, however, employment of technicians dominated staffing in the industry. As would be expected, science employment in these nondurable-goods industries was concentrated in chemical and biological professions. By 1980 economic activity, as measured by total employment, had begun to level off or decline across most 3-digit industries within the chemical-goods industry.

section 3.

measuring determinants of occupational change: industry growth and staffing patterns

Cursory analysis of the data presented in the preceding sections indicates that SET employment has increased far more than would have been anticipated given overall employment growth in manufacturing industries. Total employment in these industries increased by less than 3 percent from 1977 to 1980, while aggregate SET employment increased by roughly 20 percent. Most of the 13 manufacturing industries with declining total employment over the period registered increases, not reductions, in the number of scientists, engineers, and technicians. Even for those few, high-technology industries undergoing strong growth, increases in total employment rarely kept pace with the growth in SET personnel.

The large discrepancy between the growth in SET and overall industry employment leads to the hypothesis that, over this period, staffing patterns in these industries were changing so as to increase the utilization rate of scientists, engineers, and technicians. Few studies have been conducted to measure the relative importance of variations in staffing patterns in determining changes in occupational employment because of the scarcity of available data. Data providing the occupational and industrial detail needed for such analyses are collected infrequently because of the large sample sizes needed to provide reliable estimates.

The analyses conducted to date, generally based on decennial census data, have led to the opinion that, over the course of a decade, the change in occupational requirements within industries can be attributed equally to movements in staffing patterns and overall industrial employment activity. Although data to test this relationship for shorter periods have been unavailable, it is commonly assumed that, the shorter the time-frame, the less important are staffing pattern changes and the more dominant is total industry employment behavior.[21] The purpose of this section is to evaluate the importance of staffing pattern changes in explaining the movement of SET employment within manufacturing industries. The larger the impact of these changes relative to overall employment growth, the more important is this factor in generating future demand for SET personnel.

[21] Department of Labor, *Tomorrow's Manpower Needs*, Research Report on Manpower Projection Methods, Bulletin 1769 (Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1973); Richard B. Freeman, "An Empirical Analysis of the Fixed-Coefficient 'Manpower Requirements' Model 1960-70," *The Journal of Human Resources*, Vol. XV, No. 2, 1980; and Department of Labor, Bureau of Labor Statistics, Division of Occupational Outlook, "Projected Occupational Staffing Patterns of Industries," OES Technical Paper No. 2 (Washington, D.C., March 1981).

decomposing changes in occupational employment

Changes in occupational employment result from a combination of several factors. Other things being equal, increasing or declining employment could be expected to induce similar changes in personnel across the full range of skills within an industry. Changes in industrial employment, however, do not affect all industries equally; often one industry or group of industries grows more rapidly than others. Such changes in the composition of industrial employment also affect occupational demand. For example, faster growth in the aforementioned high-technology industries relative to other manufacturing industries serves to accelerate the increase in demand for SET personnel because of their higher concentration of SET employment. Finally, occupational employment changes can result from variations of staffing patterns within industries as skill requirements respond to changes in technology and product mix. These factors do not operate independently of one another, but occur simultaneously, making it difficult to isolate the effects of one from the other.

Employment for any occupation within any given industry can be derived as the product of that industry's total employment and staffing pattern (within an industry, the ratio of workers in that occupation to total employment). Using this derivation, changes in occupational employment between time periods t and t-1 represented by the operator Δ can be decomposed into two factors representing movements in industry employment and staffing patterns:

$$E_{ij} = (\Delta E_j)\, s_{ij,t-1} + (\Delta s_{ij})\, E_{j,t}$$

where E_{ij} is the number of people employed in occupation i within industry j; E_j is total employment in industry j; and s_{ij} represents the staffing pattern of occupation i within that industry.[22]

In the foregoing equation, the first term to the right of the equivalence sign represents that part of occupational change attributable solely to movements in industry employment (ΔE_j). This component of employment change assumes that staffing patterns remain constant.[23] If changes in occupational employment are derived by summing this relationship across industries, the ΔE_j term also picks up the effect of compositional changes in industrial employment on occupational employment demands.

The ability of industrial employment growth to explain employment change within or across industries critically depends on the stability of staffing patterns and, hence, the magnitude of the second component of change shown in the equation. This latter term allows for variations in industrial staffing (Δs_{ij}) and measures the impact of these variations on changes in occupational employment for a fixed composition of industrial employment.[24]

results

Data from the 1977 and 1980 OES Surveys of Manufacturing Industries can be used to distinguish the relative importance of movements in industrial employment and staffing patterns in determining employment changes within major SET occupational categories. The test procedure assumes that occupational structure remains constant over the period of analysis and applies 1977 staffing patterns to changes in total industry employment. (See equation in second paragraph on this page.) The resulting estimate of employment change for each occupation is then compared to the actual change which occurred. The difference between the two represents the share of the change in occupational employment caused by shifts in the staffing patterns of manufacturing industries.

In manufacturing industries, overall changes in industrial employment accounted for a substantially smaller share of SET employment growth between 1977 and 1980 than would have been anticipated from the findings of earlier studies (chart 7). Changes in staffing patterns accounted for approximately 70 percent of SET employment changes. Overall growth in industrial employment explained only 66,000 of SET employment change, roughly 30 percent of the 223,000 actual employment growth.

There was a marked difference in the importance of variations in staffing patterns in determining employment changes within various SET occupational categories; staffing pattern changes were significantly more important in explaining the changes in utilization of scientists than engineers and technicians. Between 1977 and 1980, shifts in staffing patterns explained 19,500 of the increase in the number of scientists in manufacturing industries, roughly 85 percent of the 23,000 growth in employment that actually occurred. For engineers and technicians, staffing behavior explained more than two-thirds of increasing employment levels, representing employment changes of 70,000 and 67,000, respectively, against an actual employment change of 100,000 in each field. An obvious hypothesis which could be used to explain the higher correlation between total employment and that in the latter occupations is that engineering and technician professions are more closely associated with the

---

[22] The derivation is as follows: At any given period of time (t), employment in occupation i, within industry, j, ($E_{ij,t}$) can be defined as the product of total industry employment in that time period ($E_{j,t}$) and that industry's occupational staffing pattern as measured by the ratio of the occupation's employment level to total industry employment ($E_{ij,t}/E_{j,t}$). Thus,

$$[1]\quad E_{ij,t} - E_{ij,t-1} = E_{j,t}\left[\frac{E_{ij,t}}{E_{j,t}}\right] - E_{j,t-1}\left[\frac{E_{ij,t-1}}{E_{j,t-1}}\right]$$

Letting s_{ij} represent the term for staffing patterns, equation [1] can be rewritten as:

$$[2]\quad E_{ij,t} - E_{ij,t-1} = (E_{j,t})(s_{ij,t}) - (E_{j,t-1})(s_{ij,t-1})$$

Adding and subtracting $(E_{j,t})(s_{ij,t-1})$ to the equation (which does not change the equality), combining, and rearranging terms results in:

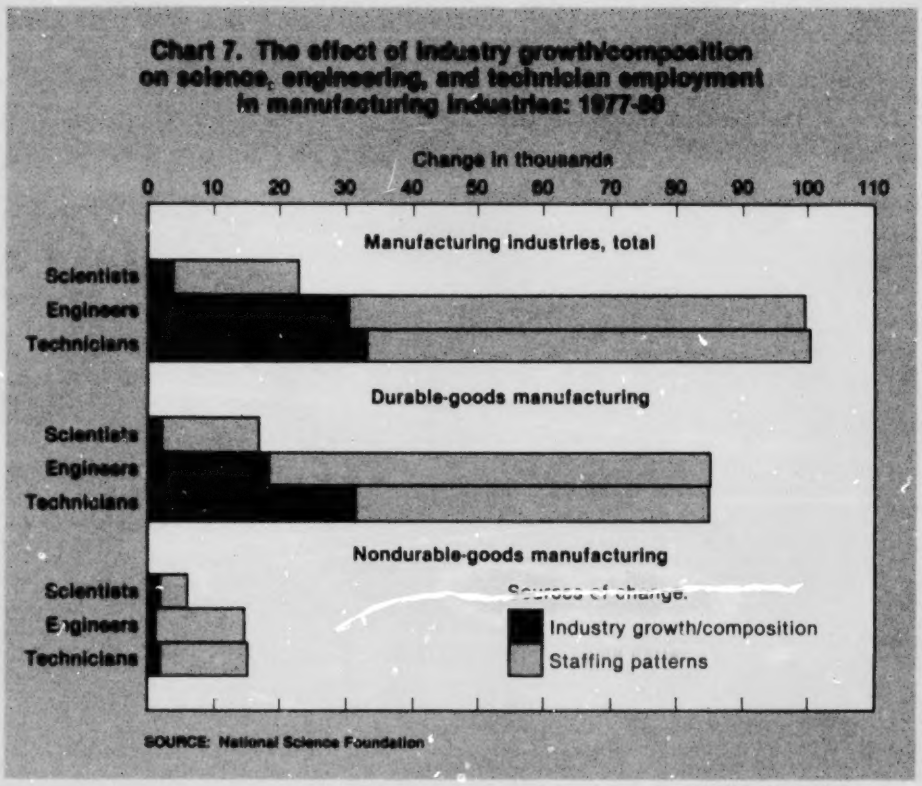
$$[3]\quad E_{ij,t} - E_{ij,t-1} = (E_{j,t} - E_{j,t-1})\, s_{ij,t-1} + - (E_{j,t})(s_{ij,t} - s_{ij,t-1})$$

Letting Δ indicate changes in a variable over time, we arrive at the equation specified in the text, namely:

$$[4]\quad E_{ij} = (\Delta E_j)(s_{ij,t-1}) + (\Delta s_{ij})(E_{j,t})$$

[23] The first term in the equation represents employment change as it would have been estimated using a fixed-coefficient employment model. Such models are used to develop estimates of detailed occupational employment when actual survey data are unavailable. The assumption underlying such models is that, within an industry, staffing patterns remain stable over relatively short periods thus making total employment the major determinant of occupational change.

[24] Theoretically, there is a third component of change, $(\Delta s_{ij})(\Delta E_j)$, which measures interaction of the two effects. The term is omitted from this analysis because of the discrete nature of the data which precludes its measurement. It is used in continuous models such as that tested by Richard B. Freeman, *op. cit.*



for computer systems analysts and programmers who benefitted from increased demand generated by rapid diffusion of computer technology. With respect to the remaining two occupations, overall growth in industrial employment explained very little of the increasing employment of industrial engineers which was generated by industry's growing concern with productivity and quality control. The number of jobs in mathematical occupations moved counter to industrial employment; they declined while overall industrial employment levels increased.

The relative performance of staffing pattern behavior varies by industry (chart 7). Staffing behavior was less important in explaining changes in occupational employment within durable-goods industries, which generated the bulk of employment growth in manufacturing industries, than in nondurable-manufacturing industries, in the majority of which employment declined in the late seventies. While variations in staffing patterns was the prime determinant of occupational change in both types of industries, they appeared relatively more important in industries with declining levels of employment.[26]

production process, forcing their employment behavior to more closely parallel general employment conditions.

Previous studies suggest that the more restrictive the definition of occupation, the more difficult it is to generalize about the relative importance of industry growth and staffing patterns in determining employment changes.[25] This is demonstrated by the eight detailed occupations chosen for analysis (table 10). In two occupations (chemists and electrical/electronic engineers), employment grew less than half as fast as the overall work force in the industries that employed them. For these occupations, changes in industrial staffing patterns reduced the utilization of these personnel relative to others. The same was true, to a lesser extent, for engineering technicians. In three occupations (mechanical engineers, computer systems analysts, and computer programmers), employment growth outpaced growth in the overall work force, and changes in staffing patterns resulted in increased utilization of such personnel.

Staffing patterns within manufacturing industries were shifting to include more SET personnel. This was especially true

[25] Department of Labor, *Tommorow's Manpower Needs*, op. cit.

[26] The exception to this appears to be for scientists where the model performs best for nondurable-goods industries. Analysis of table B-16, however, shows that this results from errors across component industries which tend to cancel one another.

Table 10—The effect of industry growth and composition on employment changes in selected science, engineering, and technician occupations

Occupation	Actual employment change[1]	Change based on industry growth/ composition	Percent of change explained by industry growth/ composition
Scientists			
Chemists	2.5	6.4	256.0
Mathematicians	-1.6	1.3	(2)
Computer systems analysts	14.9	6.1	40.9
Engineers			
Electrical/electronic	17.9	39.2	219.0
Industrial	60.1	5.6	9.3
Mechanical	14.7	8.9	60.5
Technicians			
Engineering	58.2	70.4	121.0
Computer programming	22.7	8.8	38.7

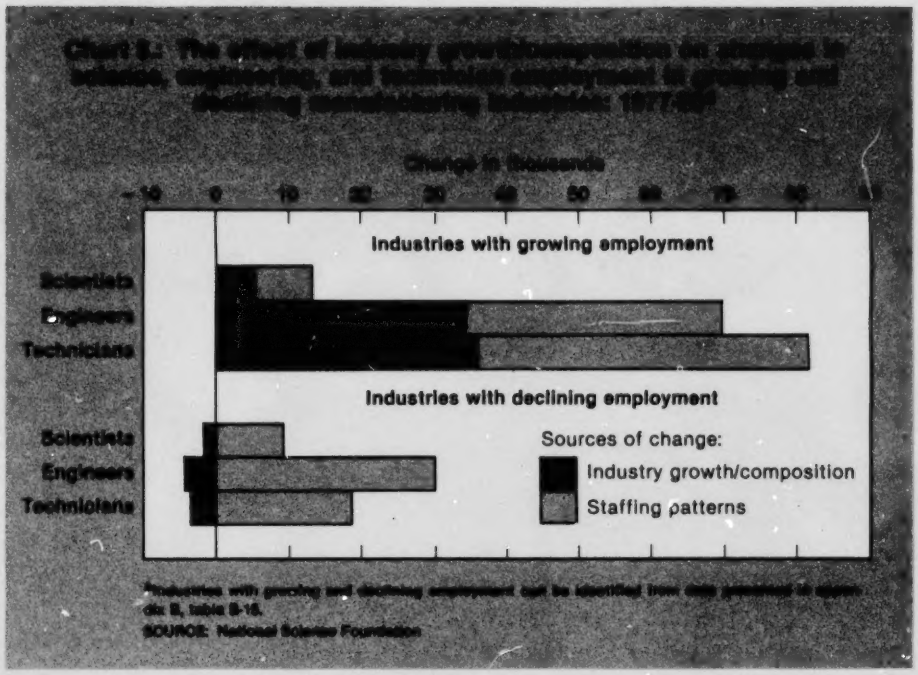
[1] Employment changes reported in thousands.
[2] Estimated change was negative because of declining industry employment.

SOURCE: National Science Foundation

To test this assumption, the 20 manufacturing industries were divided into two categories depending on the direction of changes in total employment (chart 8). In manufacturing industries with expanding employment levels, staffing behavior explained the majority of occupational employment change. Growth in industrial employment, however, explained a significant proportion of increasing occupational requirements.[27] Employment growth in these industries explained almost two-fifths of the actual change which occurred in science professions (5,000 of 13,000); almost half the change in engineering employment (34,000 of 70,000), and 53 percent of the actual change of employment in technican occupations (36,000 of 68,000).

In the remaining 13 industries, the numbers of scientists, engineers, and technicians increased while total employment declined. If the number of scientists had moved with changes in total industrial employment, a decline of 2,000 would have resulted as opposed to the increase of 9,500 which actually occurred. For engineers, the estimated decline would have been 4,000 opposed to the actual increase of 30,000; for technicians, the corresponding changes would have shown a decline of 4,000 opposed to the actual increase of 19,000.

Among the 13 industries with declining employment, the results varied significantly. In less than half, the change in the number of SET personnel mirrored the decline in total employment. This occurred less often for scientists than it did for engineers and technicians, once again suggesting that the latter two are more closely linked to production and hence total employment behavior.[28] In these industries, however, employment of SET personnel was declining more rapidly than variations in total industry employment would have led us to believe, since controlling for industry growth led to a significant understatement of the employment decline in SET fields. In the majority of the industries undergoing reductions in total employment, SET employment, in fact, grew. This growth far outweighed the reductions



in the number of SET personnel which occurred in industries with declining employment.

It is beyond the scope of this analysis to determine what factors influenced changes in staffing behavior in industries with declining employment. There are, however, a number of plausible explanations. First, for those industries having a long-term trend reduction in employment, staffing patterns could have been increasing because of technological change favoring SET personnel. Second, SET employment is not believed to be closely linked to the production process because of the dominant role played by SET personnel in nonproduction-oriented activities such as research and development, management, etc. Thus, deteriorating employment conditions may be felt in this labor market only after significant lead time has elapsed. Third, during cyclical downturns, personnel practices generally favor retaining SET personnel because these individuals are highly trained and have firm-specific skills that would be hard to replace when economic conditions turned around.[29] All these factors could contribute to the explanation of the weak relationship between movements in SET and general employment levels.

implications

The preceding analysis has shown that staffing patterns are a major determinant of changes in the demand for SET personnel and has demonstrated the need to study these patterns in order to understand the dynamics of the SET work force. Variations in these patterns must ultimately be related to such factors as technological change, product mix, relative factor costs, expectations of future economic conditions, and current industry concerns. These factors are all difficult to identify, let alone quantify; nonetheless they have a strong impact on SET utilization.

Overall employment conditions within an industry also influence changes in occupational employment, but one needs additional knowledge about how these conditions affect SET utilization and staffing. Staffing behavior may be relatively more stable when industrial employment follows a long-term trend, than over short-term business cycles. Further research relating industry growth to staffing behavior would contribute significantly in improving predictions of SET employment demand and potential labor market imbalances.

[27] Manufacturing industries with growing levels of total employment include: Primary metals; machinery (except electrical); electrical machinery; instruments; paper and paper products; printing and publishing; and chemicals.

[28] See appendix B, table B-16.

[29] For an overview of factors affecting staffing in SET occupations, see Hugh Folk, *The Shortage of Scientists and Engineers* (Lexington, Mass.: Heath Lexington Books, 1970).

appendixes

a. technical notes
b. detailed statistical tables

appendix a

technical notes

general

National estimates of employment in science, engineering, and technician (SET) occupations presented in this report are based on data from the Occupational Employment Statistics (OES) survey. The survey is part of a larger Federal/State cooperative effort designed to produce national, State, and local data on occupational employment by industry for nonfarm wage and salary workers. Within the program, the Bureau of Labor Statistics (BLS) has primary responsibility for developing survey procedures and providing technical guidance. State Employment Security Agencies implement the survey at State and local levels, developing current and projected employment statistics for their relevant labor markets. BLS conducts supplemental surveys in noncooperating States and aggregates data to provide national employment estimates.

In the midseventies, the National Science Foundation (NSF) recognized the potential of these data for providing reliable estimates of the utilization of scientists, engineers, and technicians by private industry. Data observation over time promises to provide insight into the dynamics of this labor market as occupational requirements respond to variations in growth between industries and the impact of technological and other factors within industries. Since 1977, NSF has provided financial assistance to BLS to expand the survey's coverage of SET occupations and to ensure the development of national estimates by supporting data collection in nonparticipating States.

scope of the survey

The OES survey is conducted over a 3-year cycle: Manufacturing industries are surveyed in the first year; mining, construction, financial, and various service industries in the nonmanufacturing sector are surveyed in the second; and trade, communications, transportation, and public utilities are surveyed in the third. Data in this report were derived from the 1977 and 1980 surveys of private manufacturing establishments in Standard Industrial Classification (SIC) codes 20 to 39. The reference dates of the surveys were the weeks that included April 12, May 12, or June 12, depending on the SIC of the sampled unit. Geographically, both the 1977 and 1980 surveys covered all 50 States plus the District of Columbia.

method of collection[1]

Survey schedules in the OES were mailed to personnel offices of most sample establishments. Nonrespondents were pursued by two additional mailings at 6-week intervals, after which telephone followups were attempted. Companies essential to the survey because of their size, as well as nonrespondents suspected of biasing survey estimates, received personal visits by field personnel.

Each industry being surveyed received a separate questionnaire limiting occupational detail to primary production activities. Abbreviated survey forms, further limiting the number of relevant occupations, were sent to small establishments to reduce reporting burden and encourage participation. Detailed occupations appearing on each questionnaire were grouped under broad census headings, each with a residual category for work functions not explicitly listed on the survey form. Each

[1] A description of the OES survey can be found in Department of Labor, Bureau of Labor Satistics, *Occupational Employment Statistics Handbook* (Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, April 1979).

respondent was asked to indicate any occupations with significant employment levels, which had to be enumerated in residual categories; surveys in subsequent years were updated to include such jobs explicitly.

limitations on analysis

Data collection methodology in the OES survey introduces several analysis problems that should be taken into account when interpreting these data. First, the OES survey tends to understate requirements in specific occupational fields. This occurs because an occupation will only be listed explicitly on an industry's questionnaire if it is judged to be a major job class; otherwise, it is enumerated in a residual category. Second, this same survey characteristic can be expected to overstate cross-industry differences in staffing patterns; the finer the level of detail, the more serious the problem.

The OES survey is dynamic in that it is updated to incorporate changes in occupational staffing. As desirable as such revision is for occupational planners, it introduces a problem for analysts who want to study changes in staffing patterns over time. Survey changes introduce artifical disturbances to estimates that do not reflect actual industry behavior. Additions, deletions, or even changes in job titles can affect employment estimates for closely related occupations.[2] Thus, large changes in employment levels within occupations should be interpreted with caution.

occupational and industrial classification

The OES survey collects data for approximately 1,650 occupations. The survey combines two classification systems: The Dictionary of Occupational Titles (DOT) and the 1970 Census of Population. DOT is used to develop occupational categories and definitions because of the detail in its classification scheme. Summary categories and residual groups follow the broader categories used in the Census.

Industries surveyed were classified according to the 1972 Standard Industrial Classification. Reporting establishments were categorized on the basis of major product or activity for the previous calendar year.

concepts

An establishment, such as a factory, is the primary sampling unit in the survey. In general, it represents a single physical location and primarily engages in one type of economic activity. When several, distinct activities are performed in a single location, each activity is treated as a unique establishment depending on whether separate payroll records and other criteria are met.

Employment includes full- and part-time workers; workers on paid vacation or other types of leave; workers on unpaid short-term absences; salaried officers, executives, and staff of unincorporated firms; employees temporarily assigned to other units; and employees for whom the unit is their permanent duty station. Excluded from coverage are proprietors (owners and partners of unincorporated firms), unpaid family workers, and workers on extended leave.

Occupation refers to the occupation in which employees are working rather than that for which they were trained. Skilled personnel are an exception when engaged in the sale of science and engineering (S/E) equipment; such personnel are categorized in terms of their fields of specialization. Categorization as a scientist or engineer requires that an individual be working with a level of knowledge equivalent to that acquired by completion of a 4-year college course with a major in that field, regardless of whether a college degree was ever obtained. Employees who perform multiple functions are reported only once, in the job that is believed to require the highest level of skill. Thus, a technician performing engineering tasks would be reported as an engineer. Working supervisors, who spend more than one-fifth of their time doing work similar to that performed by individuals under their supervision, are classified in the occupation most closely related to their work duties.

sampling procedures

The OES survey is a probability sample with a sampling frame based on lists of establishments filing ES-202 forms under State Unemployment Insurance systems. Because each cooperating State selects its own sample, the reference date of the sampling frame varied according to when the last sample frame was updated and the survey was conducted. The reference used for sampling in the 11 supplemental States for the 1977 survey was the first quarter of June 1976; that used for the one supplemental survey in 1980 was the first quarter of 1979.

The survey universe is stratified by industry and size of establishment unit since these characteristics are believed primary determinants of occupational staffing patterns. In total, nine size-classes were represented, based on employment levels of 1-3, 4-9, 10-19, 20-49, 50-99, 100-249, 250-499, 500-999, and 1,000 and over.

state samples

Reporting units with one to three employees were not sampled in all States. In such cases, weights for the next largest size-class were increased to represent such employment. Reporting units with 250 or more employees were included in the sample with certainty. Samples for non-certainty size-classes were developed to produce State estimates with target relative errors of 7.5 percent at one standard deviation for the 1977 survey and 10 percent to 15 percent at one standard deviation for the 1980 survey. The latter relative error options were provided to States to reduce survey costs and could be used either to set an overall sample size or sample size within a particular Standard Industrial Classification.

The accuracy and efficiency of State samples were improved through use of State-by-State coefficients of variance (CVs) estimated from previous surveys. An optimization procedure, relating total cell employment to industry size-classes,

[2] An analysis of the impact of survey revision can be found in Department of Labor, Bureau of Labor Statistics, Office of Economic Growth and Employment Projections, "Projected Occupational Staffing Patterns of Industries," OES Technical Paper (Washington, D.C., March 1981).

was used to allocate the sample to size-class employment. The samples were then collected systematically with equal probability of selection within each State/SIC/size-class.

national supplemental sample

In order to produce national employment estimates, BLS surveyed those States that chose not to participate in the OES program. In 1977, BLS surveyed 11 noncooperating States; in 1980, the number was reduced to one. Sample size for the supplemental States was developed by first determining the sample size required for national estimates in each 2-digit SIC with a target relative error at one standard deviation of 7.5 percent in 1977 and 10 percent in 1980. This was accomplished by analyzing CVs and occupational rates for a set of occupations from the previous survey. Establishments with 1,000 or more employees were included in the supplemental samples with certainty. This national SIC sample size was then allocated to the noncooperating State's size-class cells proportional to employment.

response

In 1977, there were 148,136 final eligible units in the sample, excluding establishments determined to be out of business, out of scope, etc. Usable responses were obtained from 83,814 units, producing an overall response rate of 56.7 percent based on units and 55.4 percent based on employment. In 1980, 159,672 final eligible units provided usable responses from 111,860 establishments. The 1980 response rate was 70.1 percent based on units and 70.6 percent based on weighted employment.

Subsequent to the national estimates, additional data were received by States and used in preparing State estimates. Response rates in most States were significantly higher than the response rate used to develop national totals.

estimation

A weight was determined for each sample unit from which a usable response was received. Each weight was the product of two factors: (1) The inverse of the probability of selection roughly indicating the number of establishments a survey unit represented; and, (2) adjustment for nonresponse resulting from either unreturned questionnaires or unusable information.

For each of the 3-digit SIC/State/size-class sampling cells, the nonresponse factor was calculated as a ratio:

$$\frac{\text{Weighted sample employment of all eligible units in sample}}{\text{Weighted sample employment of all responding eligible units}}$$

The sample employments were taken from the sampling frame. If the factor in a cell was greater than a predetermined maximum, the cell was collapsed with other homogeneous cells within the SIC until the factor for the combined cell was not greater than the appropriate maximum factor. If the collapsing procedure terminated before satisfying the constraint (i.e., no more cells were available to collapse), then the appropriate maximum factor was used. For the first six size-classes, homogeneous cells were determined to be other size cells within the Standard Industrial Classification and State. For remaining size-classes, homogeneous cells were determined to be other *State* cells within the Standard Industrial Classification and size-class.

A combined ratio estimate of occupational employment was used to develop national estimates using total employment as the auxiliary variable. The estimating formula is:[3]

$$P = \Sigma i \left[\frac{\Sigma_j \ \Sigma_k \ W_{ijk} \ P_{ijk}}{\Sigma_j \ \Sigma_k \ W_{ijk} \ e_{ijk}} \right] M_i;$$

where P = 2-digit industry occupational employment estimate,
i = 3-digit industry within a 2-digit industry,
j = size-class,
k = establishment,
W_{ijk} = weight after nonresponse adjustment in the ith industry, jth size-class, and kth establishment,
e_{ijk} = total employment in the ith industry, jth size-class, and kth establishment, and,
M_i = population total employment in the ith industry, obtained from the BLS Survey of Employment, Hours, and Earnings.

reliability of estimates

Estimates developed from a sample may differ from a complete survey of all establishments because of two types of errors: nonsampling and sampling. Nonsampling error can be attributed to many sources including faulty design of questionnaires, failure of respondents to provide accurate information, or problems in recording, coding, or processing data. More serious nonsampling errors result either when a chosen sample fails to represent adequately the entire population or when nonresponding units from a well-designed sample differ from survey respondents. Statistical adjustments made for nonresponding units in the latter case further exacerbate resulting biases. Careful survey design as well as effective checks and controls can eliminate some of the problems attributable to sources of nonsampling error. In general, however, the magnitude and nature of these biases are unknown.

The second type of error, sampling error, occurs because observations are made on a sample, not on the entire population. Conceptually, this error can be defined as the difference between an estimate derived from a sample and the actual value that would be expected if the entire universe were surveyed. Because actual population values are rarely observed, sampling error is approximated by the difference between the survey estimate and the average estimate that would be derived from all possible samples.

Estimates of a sample characteristic and its relative error permit construction of confidence intervals with a prescribed probability that the value from a complete coverage survey of all possible samples is

[3] Computational forms for sampling variances of combined ratios and occupational estimates can be found in National Science Foundation, *Employment of Scientists, Engineers, and Technicians in Manufacturing Industries, 1977* (Detailed Statistical Tables) (NSF 80-306) (Washington, D.C., 1980).

contained within it. The complete coverage value would be included in the range:

(1) From one standard error below to one standard error above the derived estimate for 68 percent of all samples.

(2) From two standard errors below to two standard errors above the derived estimate for 95 percent of all samples.

(3) From three standard errors below to three standard errors above the derived estimate for nearly all samples.

Sampling error in this report is expressed as relative error or the ratio of sampling error of an occupation to that occupation's employment estimate, expressed in percentage terms. As an example to demonstrate use of relative errors: Table B-2 indicates that there are 32,900 chemical scientists employed in industries producing chemical products. Table B-5 reports a 2.9-percent relative error for that industry-occupation cell. Thus, the chances are 68 out of 100 that the actual employment level would differ from the survey estimate in either direction, by 950 (.029 x 32,900); there is almost complete certainty that the survey estimate differs by no more than 2,850 (3 x .029 x 2,900) in either direction.

In this survey as in others, particular care should be exercised in the interpretation of small estimates or small differences between estimates when relatively large sampling errors are indicated.

appendix b

detailed statistical tables

page

B-1. Employment of scientists, engineers, and technicians in manufacturing industries by major occupational group: 1980 22

B-2. Employment of scientists in manufacturing industries by detailed occupation: 1980 24

B-3. Percent distribution of scientists by detailed occupation within manufacturing industries: 1980 26

B-4. Percent distribution of scientists in manufacturing industries by detailed occupation: 1980 28

B-5. Relative error as percent of employment of scientists in manufacturing industries: 1980 30

B-6. Employment of engineers in manufacturing industries by detailed occupation: 1980 32

B-7. Percent distribution of engineers by detailed occupation within manufacturing industries: 1980 34

B-8. Percent distribution of engineers in manufacturing industries by detailed occupation: 1980 ... 36

page

B-9. Relative error as percent of employment of engineers in manufacturing industries: 1980 38

B-10. Employment of technicians in manufacturing industries by detailed occupation: 1980 40

B-11. Percent distribution of technicians by detailed occupation within manufacturing industries: 1980 42

B-12. Percent distribution of technicians in manufacturing industries by detailed occupation: 1980 ... 44

B-13. Relative error as percent of employment of technicians in manufacturing industries: 1980 ... 46

B-14. Concentration ratios of scientists, engineers, and technicians in manufacturing industries: 1980 48

B-15. Growth in total, science, engineering, and technician employment in manufacturing industries: 1977-80 49

B-16. Effect of industry growth on employment change of scientists, engineers, and technicians: 1977-80 51

Table B-1

Employment of scientists, engineers, and technicians
in manufacturing industries by major occupational group: 1980

Industry	Total scientists/ engineers/ technicians	Total scien- tists	Scientists						Total engi- neers	Total tech- nicians
			Mathe- matical	Phy- sical	Life	Social	Computer analysts	Other		
	Employment [In thousands]									
Total manufacturing	1,345.1	144.7	7.6	65.4	11.1	1.2	52.6	6.7	606.1	594.3
Durable goods	1,049.6	64.6	4.8	17.7	1.0	0.9	37.1	3.1	515.3	469.7
Lumber and wood products	7.6	1.2	0.0	0.0	0.8	0.0	0.3	0.1	1.2	5.1
Furniture and fixtures	6.7	0.5	0.0	0.0	0.0	0.0	0.4	0.0	2.6	3.6
Stone, clay and glass products	20.8	2.4	0.0	1.4	0.0	0.0	0.9	0.0	8.8	9.6
Primary metals	49.3	5.1	0.0	2.4	0.0	0.0	2.4	0.3	21.9	22.3
Fabricated metal products	64.2	3.1	0.0	1.0	0.0	0.0	2.0	0.1	27.5	33.6
Machinery, except electrical	272.1	12.9	0.1	1.0	0.0	0.0	11.4	0.4	124.6	134.5
Electrical machinery	299.2	16.3	1.5	3.2	0.0	0.2	10.4	1.0	153.1	129.7
Transportation equipment	220.8	16.8	3.2	6.6	0.1	0.7	6.2	0.0	131.8	72.1
Instruments	98.6	5.4	0.0	1.7	0.0	0.0	2.6	1.1	40.3	52.8
Miscellaneous manufacturing	10.4	0.9	0.0	0.4	0.0	0.0	0.5	0.0	3.3	6.3
Nondurable goods	295.5	80.1	2.7	47.6	10.1	0.3	15.6	3.6	90.8	124.6
Food and food products	31.7	10.7	0.0	6.0	1.5	0.0	2.3	0.9	9.0	12.0
Tobacco products	2.1	0.5	0.0	0.3	0.0	0.0	0.2	0.0	0.4	1.2
Textiles	13.9	2.0	0.0	0.8	0.0	0.0	1.1	0.1	4.1	7.7
Apparel	5.7	0.7	0.0	0.0	0.0	0.0	0.6	0.0	2.7	2.3
Paper and allied products	23.7	3.7	0.0	2.1	0.0	0.0	1.0	0.6	9.5	10.5
Printing and publishing	17.7	3.1	0.5	0.3	0.0	0.2	2.1	0.0	2.0	12.6
Chemicals	151.9	51.4	2.1	32.9	8.6	0.1	5.9	1.8	41.5	59.0
Refined petroleum products	18.8	3.3	0.1	2.5	0.0	0.0	0.7	0.1	9.2	6.3
Rubber and plastic products	28.4	4.4	0.1	2.7	0.0	0.0	1.5	0.1	11.8	12.2
Leather products	1.6	0.2	0.0	0.0	0.0	0.0	0.2	0.0	0.7	0.7

Table B-1, Continued

Industry	Total scientists/ engineers/ technicians	Total scientists	Scientists						Total engineers	Total technicians
			Mathematical	Physical	Life	Social	Computer analysts	Other		
	Percent distribution									
Total manufacturing	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Durable goods	78.0	44.6	63.8	27.1	8.8	73.0	70.4	46.2	85.0	79.0
Lumber and wood products	0.8	0.9	0.0	0.0	7.4	0.0	0.6	1.6	0.2	0.9
Furniture and fixtures	0.5	0.3	0.0	0.0	0.0	0.0	0.8	0.0	0.4	0.6
Stone, clay and glass products	1.5	1.7	0.6	2.2	0.3	0.0	1.7	0.0	1.5	1.6
Primary metals	3.7	3.5	0.0	3.7	0.0	0.0	4.6	3.7	3.6	3.8
Fabricated metal products	4.8	2.1	0.0	1.5	0.0	0.0	3.7	2.2	4.5	5.7
Machinery, except electrical	20.2	8.9	1.8	1.5	0.0	0.0	21.6	6.5	20.6	22.6
Electrical machinery	22.2	11.3	19.7	4.9	0.0	12.9	19.7	15.3	25.3	21.8
Transportation equipment	16.4	11.6	41.8	10.1	1.1	60.2	11.8	0.0	21.8	12.1
Instruments	7.3	3.7	0.0	2.6	0.0	0.0	4.9	16.8	6.7	8.9
Miscellaneous manufacturing	0.8	0.6	0.0	0.6	0.0	0.0	0.9	0.0	0.5	1.1
Nondurable goods	22.0	55.4	36.2	72.9	91.2	27.0	29.6	53.8	15.0	21.0
Food and food products	2.4	7.4	0.0	9.2	13.8	2.6	4.3	12.9	1.5	2.0
Tobacco products	0.2	0.4	0.3	0.5	0.2	0.0	0.3	0.0	0.1	0.2
Textiles	1.0	1.4	0.0	1.2	0.0	0.0	2.2	1.6	0.7	1.3
Apparel	0.4	0.5	0.0	0.0	0.0	0.0	1.2	0.0	0.5	0.4
Paper and allied products	1.8	2.6	0.0	3.2	0.0	0.0	1.8	9.6	1.6	1.8
Printing and publishing	1.3	2.1	6.2	0.5	0.1	13.6	4.0	0.0	0.3	2.1
Chemicals	11.3	35.5	27.4	50.3	77.0	10.8	11.2	27.3	6.8	9.9
Refined petroleum products	1.4	2.3	0.7	3.8	0.0	0.0	1.4	1.3	1.5	1.1
Rubber and plastic products	2.1	3.0	1.5	4.1	0.0	0.0	2.9	1.1	1.9	2.1
Leather products	0.1	0.1	0.0	0.0	0.0	0.0	0.3	0.0	0.1	0.1

NOTE: Components may not add to totals because of rounding.
SOURCES: Bureau of Labor Statistics and National Science Foundation

Table B-2

Employment of scientists in manufacturing industries
by detailed occupation: 1980
[In thousands]

Industry	Total scientists	Total natural/ mathematical scientists	Natural and mathematical scientists							
			Mathematical scientists(1)	Mathematicians	Statisticians	Other mathematical	Physical scientists	Chemists	Physicists	Other physical
Total manufacturing	144.8	90.9	7.6	2.0	2.9	0.5	65.4	56.9	3.1	5.4
Durable goods	64.6	26.7	4.8	2.0	2.5	0.4	17.7	9.7	3.1	4.9
Lumber and wood products	1.2	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Furniture and fixtures	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stone, clay and glass products	2.4	1.5	0.0	0.0	0.0	0.0	1.4	1.3	0.0	0.2
Primary metals	5.1	2.7	0.0	0.0	0.0	0.0	2.4	2.4	0.0	0.0
Fabricated metal products	3.1	1.1	0.0	0.0	0.0	0.0	1.0	0.9	0.1	0.0
Machinery, except electrical	12.9	1.6	0.1	0.1	0.0	0.0	1.0	1.0	0.0	0.0
Electrical machinery	16.3	5.8	1.5	0.9	0.6	0.0	3.2	1.1	2.1	0.0
Transportation equipment	16.8	9.9	3.2	1.0	1.9	0.4	6.6	1.0	0.8	4.8
Instruments	5.4	2.8	0.0	0.0	0.0	0.0	1.7	1.7	0.0	0.0
Miscellaneous manufacturing	0.9	0.4	0.0	0.0	0.0	0.0	0.4	0.4	0.0	0.0
Nondurable goods	80.1	64.2	2.7	0.0	0.4	0.1	47.6	47.2	0.0	0.4
Food and food products	10.7	8.4	0.0	0.0	0.0	0.0	6.0	6.0	0.0	0.0
Tobacco products	0.5	0.4	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.1
Textiles	2.0	0.9	0.0	0.0	0.0	0.0	0.8	0.8	0.0	0.0
Apparel	0.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Paper and allied products	3.7	2.5	0.0	0.0	0.0	0.0	2.1	2.1	0.0	0.0
Printing and publishing	3.1	0.8	0.5	0.0	0.3	0.1	0.3	0.3	0.0	0.0
Chemicals	51.4	45.4	2.1	0.0	0.0	0.0	32.9	32.9	0.0	0.0
Refined petroleum products	3.3	2.6	0.1	0.0	0.1	0.0	2.5	2.1	0.0	0.3
Rubber and plastic products	4.4	2.9	0.1	0.0	0.0	0.0	2.7	2.7	0.0	0.0
Leather products	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table B-2, Continued

Industry	Natural and mathematical scientists					Total social scientists	Total computer systems analysts
	Life scientists	Agricultural	Biological	Medical	Other natural/ mathematical		
Total manufacturing	11.1	1.3	7.6	2.0	6.7	1.2	52.6
Durable goods	1.0	0.8	0.0	0.0	3.1	0.9	37.1
Lumber and wood products	0.8	0.8	0.0	0.0	0.1	0.0	0.3
Furniture and fixtures	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Stone, clay and glass products	0.0	0.0	0.0	0.0	0.0	0.0	0.9
Primary metals	0.0	0.0	0.0	0.0	0.3	0.0	2.4
Fabricated metal products	0.0	0.0	0.0	0.0	0.1	0.0	2.0
Machinery, except electrical	0.0	0.0	0.0	0.0	0.4	0.0	11.4
Electrical machinery	0.0	0.0	0.0	0.0	1.0	0.2	10.4
Transportation equipment	0.1	0.0	0.0	0.0	0.0	0.7	6.2
Instruments	0.0	0.0	0.0	0.0	1.1	0.0	2.6
Miscellaneous manufacturing	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Nondurable goods	10.1	0.5	7.6	2.0	3.6	0.3	15.6
Food and food products	1.5	0.0	1.5	0.0	0.9	0.0	2.3
Tobacco products	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Textiles	0.0	0.0	0.0	0.0	0.1	0.0	1.1
Apparel	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Paper and allied products	0.0	0.0	0.0	0.0	0.6	0.0	1.0
Printing and publishing	0.0	0.0	0.0	0.0	0.0	0.2	2.1
Chemicals	8.6	0.5	6.1	2.0	1.8	0.1	5.9
Refined petroleum products	0.0	0.0	0.0	0.0	0.1	0.0	0.7
Rubber and plastic products	0.0	0.0	0.0	0.0	0.1	0.0	1.5
Leather products	0.0	0.0	0.0	0.0	0.0	0.0	0.2

(1) Mathematical specialties do not sum to total. Some industries failed to disaggregate employment of mathematical scientists by subspecialty.

NOTE: Components may not add to totals because of rounding.
SOURCES: Bureau of Labor Statistics and National Science Foundation

Table B-3

Percent distribution of scientists by detailed occupation within manufacturing industries: 1980

Industry	Total scientists	Total natural/mathematical scientists	Natural and mathematical scientists							
			Mathematical scientists(1)	Mathematicians	Statisticians	Other mathematical	Physical scientists	Chemists	Physicists	Other physical
Total manufacturing	100.0	62.8	5.2	1.4	2.0	0.3	45.2	39.3	2.1	3.7
Durable goods	100.0	41.3	7.5	3.1	3.8	0.6	27.4	15.1	4.7	7.6
Lumber and wood products	100.0	76.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Furniture and fixtures	100.0	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stone, clay and glass products	100.0	62.2	1.8	0.0	0.0	0.0	59.0	52.3	0.0	6.7
Primary metals	100.0	52.7	0.0	0.0	0.0	0.0	47.8	47.8	0.0	0.0
Fabricated metal products	100.0	36.6	0.0	0.0	0.0	0.0	31.8	28.9	2.9	0.0
Machinery, except electrical	100.0	12.1	1.0	1.0	0.0	0.0	7.6	7.6	0.0	0.0
Electrical machinery	100.0	35.3	9.2	5.5	3.7	0.0	19.8	6.8	13.0	0.0
Transportation equipment	100.0	58.8	18.9	5.7	11.1	2.1	39.2	5.8	5.0	28.3
Instruments	100.0	52.0	0.0	0.0	0.0	0.0	31.0	31.0	0.0	0.0
Miscellaneous manufacturing	100.0	47.7	0.0	0.0	0.0	0.0	45.7	45.7	0.0	0.0
Nondurable goods	100.0	80.2	3.4	0.0	0.5	0.2	59.5	58.9	0.0	0.6
Food and food products	100.0	78.5	0.0	0.0	0.0	0.0	56.2	56.2	0.0	0.0
Tobacco products	100.0	71.1	4.7	0.0	0.0	0.0	61.8	46.9	0.0	14.9
Textiles	100.0	44.4	0.0	0.0	0.0	0.0	39.0	39.0	0.0	0.0
Apparel	100.0	12.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Paper and allied products	100.0	74.0	0.0	0.0	0.0	0.0	56.6	56.6	0.0	0.0
Printing and publishing	100.0	26.6	15.3	0.0	11.2	4.1	10.8	9.4	0.0	1.4
Chemicals	100.0	88.3	4.1	0.0	0.0	0.0	64.0	64.0	0.0	0.0
Refined petroleum products	100.0	77.9	1.7	0.0	1.7	0.0	73.7	64.1	0.0	9.6
Rubber and plastic products	100.0	65.6	2.6	0.0	0.0	0.0	61.4	61.4	0.0	0.0
Leather products	100.0	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table B-3, Continued

Industry	Natural and mathematical scientists					Total social scientists	Total computer systems analysts
	Life scientists	Agricultural	Biological	Medical	Other natural/mathematical		
Total manufacturing	7.7	0.9	5.3	1.3	4.7	0.8	36.4
Durable goods	1.5	1.3	0.0	0.0	4.8	1.3	57.3
Lumber and wood products	67.1	67.1	0.0	0.0	8.9	0.0	24.0
Furniture and fixtures	0.0	0.0	0.0	0.0	0.0	0.0	93.5
Stone, clay and glass products	1.3	0.0	0.0	0.0	0.0	0.0	37.8
Primary metals	0.0	0.0	0.0	0.0	4.9	0.0	47.3
Fabricated metal products	0.0	0.0	0.0	0.0	4.8	0.0	63.4
Machinery, except electrical	0.0	0.0	0.0	0.0	3.4	0.0	87.9
Electrical machinery	0.0	0.0	0.0	0.0	6.3	0.9	63.8
Transportation equipment	0.7	0.0	0.0	0.0	0.0	4.2	37.0
Instruments	0.0	0.0	0.0	0.0	21.0	0.0	48.0
Miscellaneous manufacturing	0.0	0.0	0.0	0.0	0.0	0.0	52.3
Nondurable goods	12.6	0.6	9.5	2.4	4.5	0.4	19.4
Food and food products	14.2	0.0	14.2	0.0	8.1	0.3	21.2
Tobacco products	4.7	0.0	0.0	0.0	0.0	0.0	28.9
Textiles	0.0	0.0	0.0	0.0	5.3	0.0	55.6
Apparel	0.0	0.0	0.0	0.0	0.0	0.0	87.3
Paper and allied products	0.0	0.0	0.0	0.0	17.4	0.0	26.0
Printing and publishing	0.5	0.0	0.0	0.0	0.0	5.2	68.2
Chemicals	16.7	0.9	11.9	3.8	3.6	0.2	11.5
Refined petroleum products	0.0	0.0	0.0	0.0	2.6	0.0	22.1
Rubber and plastic products	0.0	0.0	0.0	0.0	1.6	0.0	34.4
Leather products	0.0	0.0	0.0	0.0	0.0	0.0	94.6

NOTE: Components may not add to totals because of rounding.
SOURCES: Bureau of Labor Statistics and National Science Foundation

Table B-4

Percent distribution of scientists in manufacturing industries by detailed occupation: 1980

Industry	Total scientists	Total natural/mathematical scientists	Natural and mathematical scientists							
			Mathematical scientists(f)	Mathematicians	Statisticians	Other mathematical	Physical scientists	Chemists	Physicists	Other physical
Total manufacturing	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Durable goods	44.6	29.4	63.8	100.0	86.0	74.3	27.1	17.1	100.0	91.8
Lumber and wood products	0.9	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Furniture and fixtures	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stone, clay and glass products	1.7	1.7	0.6	0.0	0.0	0.0	2.2	2.2	0.0	3.0
Primary metals	3.5	2.9	0.0	0.0	0.0	0.0	3.7	4.3	0.0	0.0
Fabricated metal products	2.1	1.2	0.0	0.0	0.0	0.0	1.5	1.6	2.9	0.0
Machinery, except electrical	8.9	1.7	1.8	6.7	0.0	0.0	1.5	1.7	0.0	0.0
Electrical machinery	11.3	6.3	19.7	45.2	20.9	0.0	4.9	1.9	89.6	0.0
Transportation equipment	11.6	10.9	41.8	48.1	65.1	74.3	10.1	1.7	27.4	86.7
Instruments	3.7	3.1	0.0	0.0	0.0	0.0	2.6	2.9	0.0	0.0
Miscellaneous manufacturing	0.6	0.5	0.0	0.0	0.0	0.0	0.6	0.7	0.0	0.0
Nondurable goods	55.4	70.6	36.2	0.0	14.0	25.7	72.9	82.9	0.0	8.2
Food and food products	7.4	9.3	0.0	0.0	0.0	0.0	9.2	10.6	0.0	0.0
Tobacco products	0.4	0.4	0.3	0.0	0.0	0.0	0.5	0.4	0.0	1.5
Textiles	1.4	1.0	0.0	0.0	0.0	0.0	1.2	1.4	0.0	0.0
Apparel	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Paper and allied products	2.6	3.0	0.0	0.0	0.0	0.0	3.2	3.7	0.0	0.0
Printing and publishing	2.1	0.9	6.2	0.0	12.0	25.7	0.5	0.5	0.0	0.8
Chemicals	35.5	49.9	27.4	0.0	0.0	0.0	50.3	57.7	0.0	0.0
Refined petroleum products	2.3	2.9	0.7	0.0	2.0	0.0	3.8	3.8	0.0	5.9
Rubber and plastic products	3.0	3.2	1.5	0.0	0.0	0.0	4.1	4.7	0.0	0.0
Leather products	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table B-4, Continued

Industry	Natural and mathematical scientists					Total social scientists	Total computer systems analysts
	Life scientists	Agricultural	Biological	Medical	Other natural/ mathematical		
Total manufacturing	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Durable goods	8.8	63.3	0.0	0.0	46.2	73.0	70.4
Lumber and wood products	7.4	63.3	0.0	0.0	1.6	0.0	0.6
Furniture and fixtures	0.0	0.0	0.0	0.0	0.0	0.0	0.8
Stone, clay and glass products	0.3	0.0	0.0	0.0	0.0	0.0	1.7
Primary metals	0.0	0.0	0.0	0.0	3.7	0.0	4.6
Fabricated metal products	0.0	0.0	0.0	0.0	2.2	0.0	3.7
Machinery, except electrical	0.0	0.0	0.0	0.0	6.5	0.0	21.6
Electrical machinery	0.0	0.0	0.0	0.0	15.3	12.9	19.7
Transportation equipment	1.1	0.0	0.0	0.0	0.0	60.2	11.8
Instruments	0.0	0.0	0.0	0.0	16.8	0.0	4.9
Miscellaneous manufacturing	0.0	0.0	0.0	0.0	0.0	0.0	0.9
Nondurable goods	91.2	36.7	100.0	100.0	53.8	27.0	29.6
Food and food products	13.8	0.0	20.0	0.0	12.9	2.6	4.3
Tobacco products	0.2	0.0	0.0	0.0	0.0	0.0	0.3
Textiles	0.0	0.0	0.0	0.0	1.6	0.0	2.2
Apparel	0.0	0.0	0.0	0.0	0.0	0.0	1.2
Paper and allied products	0.0	0.0	0.0	0.0	9.6	0.0	1.8
Printing and publishing	0.1	0.0	0.0	0.0	0.0	13.6	4.0
Chemicals	77.0	36.7	80.0	100.0	27.3	10.8	11.2
Refined petroleum products	0.0	0.0	0.0	0.0	1.3	0.0	1.4
Rubber and plastic products	0.0	0.0	0.0	0.0	1.1	0.0	2.9
Leather products	0.0	0.0	0.0	0.0	0.0	0.0	0.3

NOTE: Components may not add to totals because of rounding.
SOURCES: Bureau of Labor Statistics and National Science Foundation

Table B-5

Relative error as percent of employment of scientists
in manufacturing industries: 1980

Industry	Total scientists(1)	Total natural/ mathematical scientists(1)	Natural and mathematical scientists							
			Mathematical scientists(1)	Mathematicians	Statisticians	Other mathematical	Physical scientists(1)	Chemists	Physicists	Other physical
Total manufacturing	---	---	---	---	---	---	---	---	---	---
Durable goods	---	---	---	---	---	---	---	---	---	---
Lumber and wood products	10.2	10.1	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Furniture and fixtures	11.0	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Stone, clay and glass products	11.5	11.5	32.8	(2)	(2)	(2)	11.1	8.5	(2)	31.3
Primary metals	5.2	5.2	(2)	(2)	(2)	(2)	4.3	4.3	(2)	(2)
Fabricated metal products	7.6	12.0	(2)	(2)	(2)	(2)	11.5	9.7	30.3	(2)
Machinery, except electrical	12.5	21.4	20.4	(2)	(2)	(2)	18.8	18.8	(2)	(2)
Electrical machinery	17.0	24.2	25.0	31.1	15.9	(2)	18.2	8.5	23.3	(2)
Transportation equipment	28.1	35.4	23.3	39.2	16.9	14.2	41.0	15.0	57.6	43.4
Instruments	9.8	10.1	(2)	(2)	(2)	(2)	7.8	7.8	(2)	(2)
Miscellaneous manufacturing	6.6	7.4	(2)	(2)	(2)	(2)	7.4	7.4	(2)	(2)
Nondurable goods	---	---	---	---	---	---	---	---	---	---
Food and food products	7.0	6.2	(2)	(2)	(2)	(2)	5.2	5.2	(2)	(2)
Tobacco products	24.9	27.0	25.2	(2)	(2)	(2)	27.4	21.9	(2)	44.7
Textiles	8.6	7.9	(2)	(2)	(2)	(2)	5.9	5.9	(2)	(2)
Apparel	11.9	25.8	25.8	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Paper and allied products	12.9	14.7	(2)	(2)	(2)	(2)	12.5	12.5	(2)	(2)
Printing and publishing	10.8	20.9	15.9	(2)	11.9	27.0	28.9	26.8	(2)	43.2
Chemicals	5.2	5.0	9.3	(2)	(2)	(2)	2.9	2.9	(2)	(2)
Refined petroleum products	17.2	15.0	27.1	(2)	27.1	(2)	14.2	10.3	(2)	40.3
Rubber and plastic products	24.8	21.9	22.4	(2)	(2)	(2)	21.4	21.4	(2)	(2)
Leather products	13.3	20.0	20.0	(2)	(2)	(2)	(2)	(2)	(2)	(2)

Table B-5, Continued

Industry	Natural and mathematical sdientists					Total social scientists	Total computer systems analysts
	Life scientists(1)	Agricultural	Biological	Medical	Other natural/ mathematical		
Total manufacturing	---	---	---	---	---	---	---
Durable goods	---	---	---	---	---	---	---
Lumber and wood products	7.3	7.3	(2)	(2)	30.8	(2)	10.7
Furniture and fixtures	(2)	(2)	(2)	(2)	(2)	(2)	11.8
Stone, clay and glass products	(2)	(2)	(2)	(2)	(2)	(2)	11.6
Primary metals	(2)	(2)	(2)	(2)	14.2	(2)	5.2
Fabricated metal products	(2)	(2)	(2)	(2)	14.9	(2)	5.1
Machinery, except electrical	(2)	(2)	(2)	(2)	27.7	(2)	11.2
Electrical machinery	(2)	(2)	(2)	(2)	41.6	31.7	12.9
Transportation equipment	50.2	(2)	(2)	(2)	(2)	43.9	14.6
Instruments	(2)	(2)	(2)	(2)	13.6	(2)	9.3
Miscellaneous manufacturing	(2)	(2)	(2)	(2)	(2)	(2)	5.8
Nondurable goods	---	---	---	---	---	---	---
Food and food products	5.8	(2)	5.8	(2)	14.2	37.5	9.6
Tobacco products	24.7	(2)	(2)	(2)	(2)	(2)	19.6
Textiles	(2)	(2)	(2)	(2)	22.4	(2)	9.2
Apparel	(2)	(2)	(2)	(2)	(2)	(2)	9.9
Paper and allied products	(2)	(2)	(2)	(2)	21.8	(2)	7.9
Printing and publishing	(2)	(2)	(2)	(2)	(2)	27.7	5.6
Chemicals	9.4	16.4	7.4	13.8	17.4	25.6	6.4
Refined petroleum products	(2)	(2)	(2)	(2)	30.6	(2)	24.8
Rubber and plastic products	(2)	(2)	(2)	(2)	38.4	(2)	30.4
Leather products	(2)	(2)	(2)	(2)	(2)	(2)	13.0

(1) Relative errors for aggregated fields are approximated by weighting relative errors for subspecialties.
(2) Estimated employment in this industry-occupation cell was zero.

SOURCES: Bureau of Labor Statistics and National Science Foundation

Table B-6

Employment of engineers in manufacturing industries by detailed occupation: 1980
[In thousands]

Industry	Total engineers	Aeronautical	Chemical	Civil	Electrical/electronic	Industrial
Total manufacturing	606.1	34.4	34.1	7.7	160.0	123.4
Durable goods	515.3	34.4	6.8	6.2	154.5	106.7
Lumber and wood products	1.2	0.0	0.0	0.0	0.0	0.5
Furniture and fixtures	2.6	0.0	0.0	0.0	0.0	1.4
Stone, clay and glass products	8.8	0.0	0.5	0.6	0.5	2.2
Primary metals	21.9	0.0	0.7	0.9	2.5	4.7
Fabricated metal products	27.4	0.0	0.3	1.5	1.5	8.4
Machinery, except electrical	124.6	0.0	1.1	1.6	34.2	32.3
Electrical machinery	153.1	0.0	2.2	0.0	82.6	28.3
Transportation equipment	131.8	34.4	1.0	1.7	14.3	21.8
Instruments	40.3	0.0	1.0	0.0	18.8	5.9
Miscellaneous manufacturing	3.3	0.0	0.0	0.0	0.0	1.3
Nondurable goods	90.8	0.0	27.3	1.5	5.4	16.7
Food and food products	9.0	0.0	0.6	0.0	0.0	2.5
Tobacco products	0.4	0.0	0.0	0.0	0.0	0.1
Textiles	4.1	0.0	0.0	0.0	0.0	2.1
Apparel	2.7	0.0	0.0	0.0	0.0	2.0
Paper and allied products	9.5	0.0	1.9	0.0	0.9	1.5
Printing and publishing	2.0	0.0	0.1	0.0	0.3	0.9
Chemicals	41.5	0.0	19.1	1.0	3.0	4.0
Refined petroleum products	9.2	0.0	3.7	0.5	0.4	0.5
Rubber and plastic products	11.8	0.0	2.0	0.0	0.8	2.6
Leather products	0.7	0.0	0.0	0.0	0.0	0.4

Table B-6, Continued

Industry	Mechanical	Metallurgical	Petroleum	Safety	Other
Total manufacturing.....	126.6	8.9	0.5	2.9	107.6
Durable goods.....	102.1	8.9	0.0	0.9	94.7
Lumber and wood products.....	0.3	0.0	0.0	0.0	0.4
Furniture and fixtures.....	0.6	0.0	0.0	0.0	0.6
Stone, clay and glass products	2.3	0.0	0.0	0.0	2.7
Primary metals.....	4.9	4.4	0.0	0.9	2.9
Fabricated metal products.....	11.7	0.8	0.0	0.0	3.2
Machinery, except electrical..	36.6	1.5	0.0	0.0	17.3
Electrical machinery.....	18.7	0.7	0.0	0.0	20.7
Transportation equipment.....	19.6	1.5	0.0	0.0	37.7
Instruments.....	6.0	0.0	0.0	0.0	8.6
Miscellaneous manufacturing...	1.4	0.0	0.0	0.0	0.6
Nondurable goods.....	24.5	0.0	0.5	2.0	12.9
Food and food products.....	4.5	0.0	0.0	0.0	1.3
Tobacco products.....	0.2	0.0	0.0	0.0	0.1
Textiles.....	1.2	0.0	0.0	0.0	0.8
Apparel.....	0.4	0.0	0.0	0.0	0.3
Paper and allied products.....	2.8	0.0	0.0	0.0	2.4
Printing and publishing.....	0.5	0.0	0.0	0.0	0.2
Chemicals.....	8.6	0.0	0.0	1.6	4.2
Refined petroleum products....	2.3	0.0	0.5	0.4	0.9
Rubber and plastic products...	3.9	0.0	0.0	0.0	2.6
Leather products.....	0.2	0.0	0.0	0.0	0.1

NOTE: Components may not add to totals because of rounding.
SOURCES: Bureau of Labor Statistics and National Science Foundation

Table B-7

Percent distribution of engineers by detailed occupation within manufacturing industries: 1980

Industry	Total engineers	Aeronautical	Chemical	Civil	Electrical/electronic	Industrial
Total manufacturing	100.0	5.7	5.6	1.3	26.4	20.4
Durable goods	100.0	6.7	1.3	1.2	30.0	20.7
Lumber and wood products	100.0	0.0	0.0	0.0	0.0	38.2
Furniture and fixtures	100.0	0.0	0.0	0.0	0.0	53.4
Stone, clay and glass products	100.0	0.0	5.1	6.9	6.1	25.0
Primary metals	100.0	0.0	3.2	4.1	11.6	21.2
Fabricated metal products	100.0	0.0	1.2	5.5	5.5	30.5
Machinery, except electrical	100.0	0.0	0.9	1.3	27.5	25.9
Electrical machinery	100.0	0.0	1.4	0.0	54.0	18.5
Transportation equipment	100.0	26.1	0.8	1.3	10.8	16.5
Instruments	100.0	0.0	2.5	0.0	46.7	14.6
Miscellaneous manufacturing	100.0	0.0	0.0	0.0	0.0	40.0
Nondurable goods	100.0	0.0	30.1	1.6	6.0	18.4
Food and food products	100.0	0.0	7.0	0.0	0.0	27.8
Tobacco products	100.0	0.0	0.0	0.0	0.0	28.0
Textiles	100.0	0.0	0.0	0.0	0.0	51.3
Apparel	100.0	0.0	0.0	0.0	0.0	75.0
Paper and allied products	100.0	0.0	19.6	0.0	9.9	15.6
Printing and publishing	100.0	0.0	5.2	0.0	15.2	44.7
Chemicals	100.0	0.0	45.9	2.5	7.2	9.6
Refined petroleum products	100.0	0.0	40.5	5.0	4.8	5.6
Rubber and plastic products	100.0	0.0	16.7	0.0	6.7	21.8
Leather products	100.0	0.0	0.0	0.0	0.0	67.5

Table 8-7, Continued

Industry	Mechanical	Metallurgical	Petroleum	Safety	Other engineers
Total manufacturing	20.9	1.5	0.1	0.5	17.8
Durable goods	19.8	1.7	0.0	0.2	18.4
Lumber and wood products	27.5	0.0	0.0	0.0	34.3
Furniture and fixtures	24.4	0.0	0.0	0.0	22.1
Stone, clay and glass products	26.6	0.0	0.0	0.0	30.4
Primary metals	22.2	20.1	0.0	4.1	13.4
Fabricated metal products	42.6	2.9	0.0	0.0	11.8
Machinery, except electrical	29.4	1.2	0.0	0.0	13.9
Electrical machinery	12.2	0.5	0.0	0.0	13.5
Transportation equipment	14.8	1.2	0.0	0.0	28.6
Instruments	15.0	0.0	0.0	0.0	21.2
Miscellaneous manufacturing	41.3	0.0	0.0	0.0	18.7
Nondurable goods	27.0	0.0	0.5	2.2	14.2
Food and food products	50.2	0.0	0.0	0.0	15.0
Tobacco products	50.5	0.0	0.0	0.0	21.4
Textiles	28.5	0.0	0.0	0.0	20.2
Apparel	13.8	0.0	0.0	0.0	11.2
Paper and allied products	29.7	0.0	0.0	0.0	25.1
Printing and publishing	24.9	0.0	0.0	0.0	10.0
Chemicals	20.8	0.0	0.0	3.9	10.2
Refined petroleum products	25.2	0.0	5.1	4.3	9.5
Rubber and plastic products	32.7	0.0	0.0	0.0	22.1
Leather products	23.0	0.0	0.0	0.0	9.5

NOTE: Components may not add to totals because of rounding.
SOURCES: Bureau of Labor Statistics and National Science Foundation

Table B-8

Percent distribution of engineers in manufacturing industries by detailed occupation: 1980

Industry	Total engineers	Aeronautical	Chemical	Civil	Electrical/electronic	Industrial
Total manufacturing	100.0	100.0	100.0	100.0	100.0	100.0
Durable goods	85.0	100.0	19.9	80.9	96.6	86.5
Lumber and wood products	0.2	0.0	0.0	0.0	0.0	0.4
Furniture and fixtures	0.4	0.0	0.0	0.0	0.0	1.1
Stone, clay and glass products	1.5	0.0	1.3	7.9	0.3	1.8
Primary metals	3.6	0.0	2.0	11.7	1.6	3.8
Fabricated metal products	4.5	0.0	1.0	19.5	0.9	6.8
Machinery, except electrical	20.6	0.0	3.2	20.3	21.4	26.2
Electrical machinery	25.3	0.0	6.3	0.0	51.6	23.0
Transportation equipment	21.8	100.0	3.0	21.5	8.9	17.6
Instruments	6.7	0.0	3.0	0.0	11.8	4.8
Miscellaneous manufacturing	0.5	0.0	0.0	0.0	0.0	1.1
Nondurable goods	15.0	0.0	80.1	19.1	3.4	13.5
Food and food products	1.5	0.0	1.8	0.0	0.0	2.0
Tobacco products	0.1	0.0	0.0	0.0	0.0	0.1
Textiles	0.7	0.0	0.0	0.0	0.0	1.7
Apparel	0.5	0.0	0.0	0.0	0.0	1.7
Paper and allied products	1.6	0.0	5.4	0.0	0.6	1.2
Printing and publishing	0.3	0.0	0.3	0.0	0.2	0.7
Chemicals	6.8	0.0	55.9	13.3	1.9	3.2
Refined petroleum products	1.5	0.0	10.9	5.9	0.3	0.4
Rubber and plastic products	1.9	0.0	5.8	0.0	0.5	2.1
Leather products	0.1	0.0	0.0	0.0	0.0	0.4

Table B-8, Continued

Industry	Mechanical	Metallurgical	Petroleum	Safety	Other
Total manufacturing.....	100.0	100.0	100.0	100.0	100.0
Durable goods.....	80.6	100.0	0.0	31.2	88.0
Lumber and wood products.....	0.3	0.0	0.0	0.0	0.4
Furniture and fixtures.....	0.5	0.0	0.0	0.0	0.5
Stone, clay and glass products	1.9	0.0	0.0	0.0	2.5
Primary metals.....	3.8	49.3	0.0	31.2	2.7
Fabricated metal products.....	9.2	8.9	0.0	0.0	3.0
Machinery, except electrical..	28.9	16.9	0.0	0.0	16.1
Electrical machinery.....	14.8	7.9	0.0	0.0	19.2
Transportation equipment.....	15.4	17.0	0.0	0.0	35.0
Instruments.....	4.8	0.0	0.0	0.0	8.0
Miscellaneous manufacturing...	1.1	0.0	0.0	0.0	0.5
Nondurable goods.....	19.4	0.0	100.0	68.8	12.0
Food and food products.....	3.6	0.0	0.0	0.0	1.2
Tobacco products.....	0.1	0.0	0.0	0.0	0.1
Textiles.....	0.9	0.0	0.0	0.0	0.7
Apparel.....	0.3	0.0	0.0	0.0	0.3
Paper and allied products.....	2.2	0.0	0.0	0.0	2.2
Printing and publishing.....	0.4	0.0	0.0	0.0	0.2
Chemicals.....	6.8	0.0	0.0	55.2	3.9
Refined petroleum products....	1.8	0.0	100.0	13.6	0.8
Rubber and plastic products...	3.0	0.0	0.0	0.0	2.4
Leather products.....	0.1	0.0	0.0	0.0	0.1

NOTE: Components may not add to totals because of rounding.
SOURCES: Bureau of Labor Statistics and National Science Foundation

Table B-9

Relative error as percent of employment of engineers in manufacturing industries: 1980

Industry	Total engineers(1)	Aeronautical	Chemical	Civil	Electrical/electronic	Industrial
Total manufacturing	---	---	---	---	---	---
Durable goods	---	---	---	---	---	---
Lumber and wood products	6.4	(2)	(2)	(2)	(2)	6.4
Furniture and fixtures	6.7	(2)	(2)	(2)	(2)	5.3
Stone, clay and glass products	11.0	(2)	11.0	7.7	8.7	7.3
Primary metals	5.4	(2)	6.4	10.6	6.7	3.8
Fabricated metal products	5.7	(2)	8.7	8.9	8.9	3.0
Machinery, except electrical	4.6	(2)	10.3	11.2	1.1	5.8
Electrical machinery	6.4	(2)	15.4	(2)	2.4	9.3
Transportation equipment	9.3	7.5	26.1	21.4	18.2	9.9
Instruments	9.8	(2)	11.6	(2)	7.9	11.0
Miscellaneous manufacturing	6.5	(2)	(2)	(2)	(2)	5.8
Nondurable goods	---	---	---	---	---	---
Food and food products	5.1	(2)	10.0	(2)	(2)	3.7
Tobacco products	16.1	(2)	(2)	(2)	(2)	17.0
Textiles	4.3	(2)	(2)	(2)	(2)	3.0
Apparel	5.3	(2)	(2)	(2)	(2)	2.8
Paper and allied products	11.9	(2)	6.1	(2)	6.6	3.5
Printing and publishing	13.0	(2)	21.9	(2)	13.7	11.3
Chemicals	5.3	(2)	3.9	9.2	7.4	5.5
Refined petroleum products	12.9	(2)	10.9	16.2	11.9	19.5
Rubber and plastic products	13.2	(2)	24.4	(2)	15.9	5.4
Leather products	7.0	(2)	(2)	(2)	(2)	5.8

Table B-9, Continued

Industry	Mechanical	Metallurgical	Petroleum	Safety	Other engineers
Total manufacturing	---	---	---	---	---
Durable goods	---	---	---	---	---
Lumber and wood products	6.0	(2)	(2)	(2)	6.7
Furniture and fixtures	8.1	(2)	(2)	(2)	8.6
Stone, clay and glass products	9.7	(2)	(2)	(2)	16.5
Primary metals	4.6	4.4	(2)	4.7	8.1
Fabricated metal products	3.4	7.9	(2)	(2)	16.7
Machinery, except electrical	3.3	7.2	(2)	(2)	10.6
Electrical machinery	7.4	11.6	(2)	(2)	16.3
Transportation equipment	8.7	15.5	(2)	(2)	6.5
Instruments	6.0	(2)	(2)	(2)	15.4
Miscellaneous manufacturing	5.5	(2)	(2)	(2)	10.1
Nondurable goods	---	---	---	---	---
Food and food products	3.8	(2)	(2)	(2)	10.1
Tobacco products	15.6	(2)	(2)	(2)	15.9
Textiles	4.4	(2)	(2)	(2)	7.8
Apparel	8.8	(2)	(2)	(2)	17.7
Paper and allied products	4.8	(2)	(2)	(2)	32.1
Printing and publishing	10.9	(2)	(2)	(2)	19.8
Chemicals	5.7	(2)	(2)	3.6	9.2
Refined petroleum products	11.2	(2)	24.1	12.0	15.0
Rubber and plastic products	14.2	(2)	(2)	(2)	10.3
Leather products	9.7	(2)	(2)	(2)	9.3

(1) Relative errors for total engineers are approximated by weighting relative errors of subspecialties.
(2) Estimated employment in this industry-occupation cell was zero.

SOURCES: Bureau of Labor Statistics and National Science Foundation

Table B-10

Employment of technicians in manufacturing industries by detailed occupation: 1980
[In thousands]

Industry	Total technicians	Total science	Total engineering	Engineering technicians		
				Drafters	Electrical/ electronic	Mechanical
Total manufacturing	594.3	71.4	389.0	119.7	135.9	34.6
Durable goods	469.7	19.3	352.4	106.1	131.4	34.6
Lumber and wood products	5.1	2.0	1.9	1.7	0.0	0.0
Furniture and fixtures	3.6	0.0	2.5	2.0	0.0	0.0
Stone, clay and glass products	9.6	1.8	5.6	2.7	0.7	0.6
Primary metals	22.3	4.3	13.7	3.7	2.2	0.8
Fabricated metal products	33.6	1.5	27.1	18.8	1.5	2.3
Machinery, except electrical	134.5	2.1	98.3	35.8	33.3	9.0
Electrical machinery	129.7	2.6	107.4	19.8	62.0	8.3
Transportation equipment	72.1	1.7	55.3	12.8	12.2	10.8
Instruments	52.8	2.7	36.5	7.2	18.2	2.7
Miscellaneous manufacturing	6.3	0.4	4.1	1.7	1.4	0.0
Nondurable goods	124.6	52.1	36.6	13.6	4.5	0.0
Food and food products	12.0	5.3	2.2	0.9	0.0	0.0
Tobacco products	1.2	0.3	0.6	0.1	0.2	0.0
Textiles	7.7	4.4	1.1	0.0	0.0	0.0
Apparel	2.3	0.3	0.8	0.0	0.0	0.0
Paper and allied products	10.5	2.7	2.6	1.1	0.0	0.0
Printing and publishing	12.6	0.1	7.4	5.4	1.6	0.0
Chemicals	59.0	34.3	13.5	3.5	2.4	0.0
Refined petroleum products	6.3	2.0	2.8	0.8	0.3	0.0
Rubber and plastic products	12.2	2.9	5.4	1.7	0.0	0.0
Leather products	0.7	0.0	0.3	0.0	0.0	0.0

Table B-10, Continued

Industry	Engineering technicians			Total computer programmers	Total other technicians
	Tool programmers	Industrial	Other engineering		
Total manufacturing	10.0	17.9	68.6	72.7	61.3
Durable goods	10.0	16.4	53.8	57.2	40.8
Lumber and wood products	0.0	0.0	0.3	0.4	0.7
Furniture and fixtures	0.0	0.0	0.5	0.8	0.2
Stone, clay and glass products	0.0	0.4	1.1	0.8	1.3
Primary metals	0.4	1.8	4.8	2.0	2.4
Fabricated metal products	1.1	0.0	3.4	2.7	2.3
Machinery, except electrical	4.4	5.7	10.1	28.5	5.7
Electrical machinery	1.3	3.3	12.7	12.8	6.8
Transportation equipment	2.1	4.0	13.3	5.5	9.6
Instruments	0.5	1.2	6.7	2.9	10.6
Miscellaneous manufacturing	0.2	0.0	0.8	0.7	1.0
Nondurable goods	0.0	1.5	14.8	15.5	20.4
Food and food products	0.0	0.0	1.3	2.1	2.5
Tobacco products	0.0	0.0	0.3	0.1	0.2
Textiles	0.0	0.0	0.0	1.0	1.3
Apparel	0.0	0.0	0.0	1.0	0.2
Paper and allied products	0.0	0.0	1.5	1.0	4.3
Printing and publishing	0.0	0.0	0.3	4.2	0.9
Chemicals	0.0	0.8	6.8	4.1	7.2
Refined petroleum products	0.0	0.0	1.8	0.4	1.1
Rubber and plastic products	0.0	0.8	2.9	1.4	2.6
Leather products	0.0	0.0	0.0	0.3	0.1

NOTE: Components may not add to totals because of rounding.
SOURCES: Bureau of Labor Statistics and National Science Foundation

Table B-11

Percent distribution of technicians by detailed occupation within manufacturing industries: 1980

Industry	Total technicians	Total science	Total engineering	Engineering technicians		
				Drafters	Electrical/ electronic	Mechanical
Total manufacturing	100.0	12.0	65.5	20.1	22.9	5.8
Durable goods	100.0	4.1	75.0	22.6	28.0	7.4
Lumber and wood products	100.0	39.9	37.9	32.6	0.0	0.0
Furniture and fixtures	100.0	0.9	70.2	55.7	0.0	0.0
Stone, clay and glass products	100.0	19.0	58.1	28.6	7.3	6.8
Primary metals	100.0	19.2	61.2	16.6	9.8	3.6
Fabricated metal products	100.0	4.5	80.6	55.9	4.4	6.7
Machinery, except electrical	100.0	1.6	73.1	26.6	24.8	6.7
Electrical machinery	100.0	2.0	82.8	15.3	47.8	6.4
Transportation equipment	100.0	2.4	76.7	17.8	16.9	15.0
Instruments	100.0	5.2	69.1	13.6	34.4	5.1
Miscellaneous manufacturing	100.0	6.5	64.9	26.9	21.9	0.0
Nondurable goods	100.0	41.8	29.4	10.9	3.6	0.0
Food and food products	100.0	43.8	18.1	7.7	0.0	0.0
Tobacco products	100.0	25.9	52.2	10.6	18.9	0.0
Textiles	100.0	56.5	13.9	0.0	0.0	0.0
Apparel	100.0	11.2	34.7	0.0	0.0	0.0
Paper and allied products	100.0	25.4	24.5	10.5	0.0	0.0
Printing and publishing	100.0	0.8	58.3	43.1	12.6	0.0
Chemicals	100.0	58.1	22.8	5.9	4.1	0.0
Refined petroleum products	100.0	31.0	45.2	12.4	4.5	0.0
Rubber and plastic products	100.0	23.4	44.3	14.3	0.0	0.0
Leather products	100.0	5.3	41.3	0.0	0.0	0.0

Table B-11, Continued

Industry	Engineering technicians			Total computer programmers	Total other technicians
	Tool programmers	Industrial	Other engineering		
Total manufacturing	1.7	3.0	11.5	12.2	10.3
Durable goods	2.1	3.5	11.5	12.2	8.7
Lumber and wood products	0.0	0.0	5.3	7.6	14.6
Furniture and fixtures	0.0	0.0	14.5	22.1	6.8
Stone, clay and glass products	0.0	4.4	11.1	8.9	14.0
Primary metals	1.7	8.2	21.4	8.8	10.7
Fabricated metal products	3.3	0.0	10.2	8.2	6.7
Machinery, except electrical	3.3	4.2	7.5	21.1	4.2
Electrical machinery	1.0	2.5	9.8	9.9	5.3
Transportation equipment	2.9	5.5	18.5	7.6	13.4
Instruments	1.0	2.3	12.8	5.6	20.1
Miscellaneous manufacturing	2.6	0.0	13.5	11.9	16.7
Nondurable goods	0.0	1.2	11.9	12.4	16.4
Food and food products	0.0	0.0	10.5	17.6	20.5
Tobacco products	0.0	0.0	22.7	5.2	16.7
Textiles	0.0	0.0	0.0	12.4	17.2
Apparel	0.0	0.0	0.0	44.0	10.2
Paper and allied products	0.0	0.0	14.0	9.6	40.6
Printing and publishing	0.0	0.0	2.6	33.7	7.3
Chemicals	0.0	1.3	11.5	6.9	12.2
Refined petroleum products	0.0	0.0	28.3	6.0	17.9
Rubber and plastic products	0.0	6.3	23.8	11.3	20.9
Leather products	0.0	0.0	0.0	37.4	16.1

NOTE: Components may not add to totals because of rounding.
SOURCES: Bureau of Labor Statistics and National Science Foundation

Table B-12

Percent distribution of technicians in manufacturing industries by detailed occupation: 1980

Industry	Total technicians	Total science	Total engineering	Engineering technicians		
				Drafters	Electrical/ electronic	Mechanical
Total manufacturing	100.0	100.0	100.0	100.0	100.0	100.0
Durable goods	79.0	27.0	90.6	88.6	96.7	100.0
Lumber and wood products	0.9	2.8	0.5	1.4	0.0	0.0
Furniture and fixtures	0.6	0.0	0.7	1.7	0.0	0.0
Stone, clay and glass products	1.6	2.5	1.4	2.3	0.5	1.9
Primary metals	3.8	6.0	3.5	3.1	1.6	2.3
Fabricated metal products	5.7	2.1	7.0	15.7	1.1	6.5
Machinery, except electrical	22.6	3.0	25.3	29.9	24.5	26.1
Electrical machinery	21.8	3.7	27.6	16.5	45.6	24.1
Transportation equipment	12.1	2.4	14.2	10.7	9.0	31.3
Instruments	8.9	3.8	9.4	6.0	13.4	7.8
Miscellaneous manufacturing	1.1	0.6	1.0	1.4	1.0	0.0
Nondurable goods	21.0	73.0	9.4	11.4	3.3	0.0
Food and food products	2.0	7.4	0.6	0.8	0.0	0.0
Tobacco products	0.2	0.4	0.2	0.1	0.2	0.0
Textiles	1.3	6.1	0.3	0.0	0.0	0.0
Apparel	0.4	0.4	0.2	0.0	0.0	0.0
Paper and allied products	1.8	3.7	0.7	0.9	0.0	0.0
Printing and publishing	2.1	0.1	1.9	4.5	1.2	0.0
Chemicals	9.9	48.0	3.5	2.9	1.8	0.0
Refined petroleum products	1.1	2.7	0.7	0.7	0.2	0.0
Rubber and plastic products	2.1	4.0	1.4	1.5	0.0	0.0
Leather products	0.1	0.1	0.1	0.0	0.0	0.0

Table B-12, Continued

Industry	Engineering technicians			Total computer programmers	Total other technicians
	Tool programmers	Industrial	Other engineering		
Total manufacturing	100.0	100.0	100.0	100.0	100.0
Durable goods	100.0	91.4	78.4	78.7	66.7
Lumber and wood products	0.0	0.0	0.4	0.5	1.2
Furniture and fixtures	0.0	0.0	0.8	1.1	0.4
Stone, clay and glass products	0.0	2.3	1.5	1.2	2.2
Primary metals	3.9	10.2	7.0	2.7	3.9
Fabricated metal products	11.2	0.0	5.0	3.8	3.7
Machinery, except electrical	44.0	31.7	14.8	39.1	9.3
Electrical machinery	13.1	18.4	18.5	17.7	11.2
Transportation equipment	21.0	22.1	19.4	7.5	15.7
Instruments	5.2	6.7	9.8	4.0	17.4
Miscellaneous manufacturing	1.6	0.0	1.2	1.0	1.7
Nondurable goods	0.0	8.6	21.6	21.3	33.3
Food and food products	0.0	0.0	1.8	2.9	4.0
Tobacco products	0.0	0.0	0.4	0.1	0.3
Textiles	0.0	0.0	0.0	1.3	2.2
Apparel	0.0	0.0	0.0	1.4	0.4
Paper and allied products	0.0	0.0	2.1	1.4	7.0
Printing and publishing	0.0	0.0	0.5	5.8	1.5
Chemicals	0.0	4.3	9.9	5.6	11.8
Refined petroleum products	0.0	0.0	2.6	0.5	1.8
Rubber and plastic products	0.0	4.3	4.2	1.9	4.2
Leather products	0.0	0.0	0.0	0.4	0.2

NOTE: Components may not add to totals because of rounding.
SOURCES: Bureau of Labor Statistics and National Science Foundation

Table B-13

Relative error as percent of employment of technicians in manufacturing industries: 1980

Industry	Total technicians(1)	Total science	Total engineering(1)	Engineering technicians		
				Drafters	Electrical/ electronic	Mechanical
Total manufacturing	---	---	---	---	---	---
Durable goods	---	---	---	---	---	---
Lumber and wood products	6.6	7.8	5.0	4.5	(2)	(2)
Furniture and fixtures	7.4	34.1	5.8	4.6	(2)	(2)
Stone, clay and glass products	10.5	12.9	10.3	4.6	11.8	21.9
Primary metals	6.6	6.1	6.8	3.6	9.5	8.7
Fabricated metal products	4.9	13.7	4.0	2.6	8.6	7.3
Machinery, except electrical	7.1	12.8	5.2	2.4	5.8	8.0
Electrical machinery	8.1	13.0	6.7	4.2	5.1	8.3
Transportation equipment	19.7	20.4	19.0	14.1	24.8	20.6
Instruments	7.8	11.1	7.7	3.8	7.1	7.3
Miscellaneous manufacturing	7.0	11.0	6.8	7.7	9.2	(2)
Nondurable goods	---	---	---	---	---	---
Food and food products	6.9	7.6	7.0	6.0	(2)	(2)
Tobacco products	25.5	25.6	26.2	17.5	18.3	(2)
Textiles	4.3	5.0	5.5	(2)	(2)	(2)
Apparel	2.0	18.0	7.8	(2)	(2)	(2)
Paper and allied products	13.1	20.8	10.5	9.1	(2)	(2)
Printing and publishing	6.8	40.1	6.7	5.9	6.8	(2)
Chemicals	7.7	7.8	7.9	10.4	8.3	(2)
Refined petroleum products	16.5	12.6	17.9	10.0	18.5	(2)
Rubber and plastic products	16.1	9.5	14.1	7.9	(2)	(2)
Leather products	1.3	31.5	26.0	(2)	(2)	(2)

Table B-13, Continued

Industry	Engineering technicians			Total computer programmers	Total other technicians
	Tool programmers	Industrial	Other engineering		
Total manufacturing	---	---	---	---	---
Durable goods	---	---	---	---	---
Lumber and wood products	(2)	(2)	8.1	9.2	5.7
Furniture and fixtures	(2)	(2)	10.5	8.3	16.9
Stone, clay and glass products	(2)	13.1	15.6	5.5	11.6
Primary metals	12.4	6.8	7.3	5.1	8.0
Fabricated metal products	4.9	(2)	7.0	4.4	10.8
Machinery, except electrical	4.1	6.5	10.0	12.9	10.4
Electrical machinery	7.6	9.6	17.0	13.2	17.4
Transportation equipment	18.7	21.7	16.5	12.3	27.6
Instruments	8.3	14.1	12.7	6.3	7.6
Miscellaneous manufacturing	12.6	8.8	(2)	6.2	6.7
Nondurable goods	---	---	---	---	---
Food and food products	(2)	(2)	7.7	4.2	7.8
Tobacco products	(2)	(2)	36.9	11.5	27.5
Textiles	(2)	(2)	(2)	6.0	9.6
Apparel	(2)	(2)	(2)	6.7	16.0
Paper and allied products	(2)	(2)	11.7	5.4	11.8
Printing and publishing	(2)	(2)	20.9	5.3	11.0
Chemicals	(2)	10.8	6.2	5.4	8.3
Refined petroleum products	(2)	(2)	21.2	17.4	19.6
Rubber and plastic products	(2)	14.3	8.8	20.5	25.4
Leather products	(2)	(2)	(2)	11.4	17.1

(1) Relative errors for aggregated fields are approximated by weighting relative errors of subspecialties.
(2) Estimated employment in this industry-occupation cell was zero.

SOURCES: Bureau of Labor Statistics and National Science Foundation

Table B-14

Concentration ratios of scientists, engineers, and technicians in manufacturing industries: 1980

Industry	Total scientists/ engineers/ technicians	Total scientists/ engineers	Scientists	Engineers	Technicians
Total manufacturing	1.0	1.0	1.0	1.0	1.0
Durable goods	1.3	1.3	0.7	1.4	1.3
Lumber and wood products	0.2	0.1	0.3	0.1	0.3
Furniture and fixtures	0.2	0.2	0.1	0.2	0.3
Stone, clay and glass products	0.5	0.5	0.5	0.4	0.5
Primary metals	0.6	0.6	0.6	0.6	0.6
Fabricated metal products	0.6	0.5	0.3	0.6	0.7
Machinery, except electrical	1.6	1.5	0.7	1.7	1.8
Electrical machinery	2.2	2.2	1.1	2.5	2.1
Transportation equipment	1.8	2.2	1.3	2.4	1.3
Instruments	2.1	1.7	1.1	1.9	2.5
Miscellaneous manufacturing	0.4	0.3	0.3	0.3	0.5
Nondurable goods	0.5	0.6	1.4	0.4	0.5
Food and food products	0.3	0.3	0.9	0.2	0.2
Tobacco products	0.5	0.4	1.2	0.2	0.7
Textiles	0.2	0.2	0.3	0.2	0.3
Apparel	0.1	0.1	0.1	0.1	0.1
Paper and allied products	0.5	0.5	0.7	0.5	0.5
Printing and publishing	0.2	0.1	0.3	0.1	0.3
Chemicals	2.0	2.2	6.4	1.2	1.8
Refined petroleum products	1.4	1.7	2.3	1.5	1.1
Rubber and plastic products	0.6	0.6	0.9	0.6	0.6
Leather products	0.1	0.1	0.1	0.1	0.1

NOTE: A concentration ratio relates the proportion of scientists, engineers, and/or technicians employed in each industry to that industry's proportion of total manufacturing employment. More formally,

$$C(i)=[(S(i)/S)/(E(i)/E)],$$

where C(i), S(i) and E(i) represent the concentration ratio, the number of scientists, engineers, and/or technicians and total employment in industry i, respectively. The letter, S, represents the total number of scientists, engineers, and/or technicians in manufacturing industries; E represents total manufacturing employment.

SOURCE: National Science Foundation

Table B-15

Growth of total, science, engineering, and technician employment in manufacturing industries: 1977-80
[In thousands]

Industry	Total employment			Scientists		
	1977	1980	Percent change	1977	1980	Percent change
Total manufacturing	19,721.4	20,228.3	2.6	121.9	144.7	18.7
Durable goods	11,621.8	12,107.8	4.2	47.7	64.6	35.5
Lumber and wood products	714.4	657.3	-8.0	1.2	1.2	2.7
Furniture and fixtures	462.7	455.9	-1.5	0.3	0.5	59.0
Stone, clay and glass products	670.9	665.7	-0.8	2.1	2.4	15.3
Primary metals	1,180.9	1,205.2	2.1	4.1	5.1	24.0
Fabricated metal products	1,588.6	1,580.0	-0.5	3.5	3.1	-11.8
Machinery, except electrical	2,174.1	2,497.4	14.9	9.8	12.9	31.9
Electrical machinery	1,882.7	2,079.7	10.5	10.7	16.3	52.3
Transportation equipment	1,889.4	1,835.1	-2.9	10.9	16.8	54.3
Instruments	618.9	709.8	14.7	4.6	5.4	17.7
Miscellaneous manufacturing	439.2	421.9	-4.0	0.5	0.9	73.2
Nondurable goods	8,099.6	8,120.6	0.3	74.2	80.1	8.0
Food and food products	1,710.9	1,694.9	-0.9	6.2	10.7	73.2
Tobacco products	70.9	63.6	-10.4	1.0	0.5	-46.3
Textiles	913.7	870.9	-4.7	1.9	2.0	7.4
Apparel	1,318.7	1,271.4	-3.6	0.4	0.7	85.5
Paper and allied products	686.1	698.9	1.9	2.6	3.7	43.6
Printing and publishing	1,132.9	1,254.3	10.7	2.3	3.1	33.3
Chemicals	1,082.0	1,116.8	3.2	50.4	51.4	1.9
Refined petroleum products	202.8	202.7	-0.1	6.4	3.3	-47.9
Rubber and plastic products	721.5	711.0	-1.5	2.6	4.4	69.1
Leather products	260.0	236.3	-9.1	0.2	0.2	-7.5

Table B-15. Continued

Industry	Engineers			Technicians		
	1977	1980	Percent change	1977	1980	Percent change
Total manufacturing	506.0	606.1	19.8	494.2	594.3	20.3
Durable goods	429.8	515.3	19.9	384.6	469.7	22.1
Lumber and wood products	1.5	1.2	-17.4	6.0	5.1	-15.3
Furniture and fixtures	2.2	2.6	18.5	3.2	3.6	12.8
Stone, clay and glass products	6.7	8.8	31.9	8.0	9.6	19.6
Primary metals	19.8	21.9	10.7	19.7	22.3	13.3
Fabricated metal products	28.7	27.5	-4.4	33.4	33.6	0.7
Machinery, except electrical	95.7	124.6	30.2	116.1	134.5	15.9
Electrical machinery	127.6	153.1	20.0	102.3	129.7	26.8
Transportation equipment	111.1	131.8	18.7	56.8	72.1	26.9
Instruments	34.3	40.3	17.6	36.4	52.8	45.2
Miscellaneous manufacturing	2.2	3.3	49.0	2.6	6.3	141.1
Nondurable goods	76.2	90.8	19.2	109.6	124.6	13.7
Food and food products	3.5	9.0	156.5	12.4	12.0	-3.2
Tobacco products	0.6	0.4	-39.3	1.8	1.2	-31.8
Textiles	4.2	4.1	-1.9	7.8	7.7	-0.7
Apparel	2.8	2.7	-2.4	1.9	2.3	18.9
Paper and allied products	6.7	9.5	41.2	5.6	10.5	87.6
Printing and publishing	1.5	2.0	34.3	5.3	12.6	138.1
Chemicals	37.4	41.5	11.0	54.7	59.0	7.9
Refined petroleum products	10.3	9.2	-11.1	8.2	6.3	-23.2
Rubber and plastic products	8.8	11.8	34.1	11.5	12.2	6.1
Leather products	0.5	0.7	32.8	0.4	0.7	80.5

SOURCES: Bureau of Labor Statistics and National Science Foundation

Table B-16—Effect of industry growth on employment change of scientists, engineers, and technicians: 1977-80

Industry	Direction of total industry, employment change	Scientists			Engineers			Technicians		
		Actual employment change[1]	Estimated employment change	Percent of change explained by industry growth[2]	Actual employment change[1]	Estimated employment change	Percent of change explained by industry growth[2]	Actual employment change[1]	Estimated employment change	Percent of change explained by industry growth[2]
Total manufacturing	+	22.8	3.5	15.3	99.9	30.1	30.1	100.3	32.9	32.6
Durable goods	+	16.9	2.0	11.8	85.5	18.0	21.0	85.4	31.2	36.5
Lumber and wood products	-	.0	-1.0	(3)	-.3	-.1	33.3	-.9	-.5	55.6
Furniture and fixtures	-	.2	-.0	(3)	.4	-.0	(3)	.4	-.0	(3)
Stone, clay, and glass products	-	.3	-.0	(3)	2.1	-.1	(3)	1.6	-.1	(3)
Primary metals	+	1.0	.1	10.0	2.1	.4	19.0	2.6	.4	15.4
Fabricated metal products	-	-.4	-.0	4.6	-1.2	-.2	16.7	.2	-0.2	(3)
Machinery, except electrical	+	3.1	1.5	48.4	28.9	14.2	49.1	18.4	17.3	94.0
Electrical machinery	+	5.6	1.1	20.0	25.5	13.3	52.1	27.7	10.7	38.6
Transportation equipment	-	5.9	-.3	(3)	20.7	-3.2	(3)	15.3	-1.6	(3)
Instruments	+	.8	.7	87.5	6.0	5.0	83.3	16.4	5.3	32.3
Miscellaneous manufacturing	-	.4	-.0	(3)	1.1	-.01	(3)	3.7	-0.1	(3)
Nondurable goods	+	5.9	1.5	25.4	14.6	.9	6.2	14.9	1.5	10.1
Food and food products	-	4.5	-.1	(3)	5.5	-.0	(3)	-.4	-.1	25.0
Tobacco products	-	-.5	-.1	20.0	-.2	-.1	50.0	-.6	-.2	33.3
Textiles	-	.1	-.1	(3)	-.1	-.2	200.0	-.1	-.4	400.0
Apparel	-	.3	-.0	(3)	-.1	-.1	100.0	.4	-.1	(3)
Paper and allied products	+	1.1	.0	4.3	2.8	.1	3.6	4.9	.1	2.0
Printing and publishing	+	.7	.2	28.5	.5	0.2	40.0	7.3	.6	8.2
Chemicals	+	1.0	1.6	160.0	4.1	1.2	29.3	4.3	1.8	41.9
Refined petroleum products	-	-3.1	-.0	.1	-1.1	-.0	.0	-1.9	-.0	.0
Rubber and plastic products	-	1.8	-.0	(3)	3.0	-.1	(3)	.7	-.2	(3)
Leather products	-	.0	-.0	(4)	.2	-.1	(3)	.3	-.0	(3)

[1] All employment changes are reported in thousands.
[2] Percent change explained by industry growth is derived by dividing estimated by actual employment change.
[3] Estimated change is negative as a result of declining industry employment; actual SET growth was positive.
[4] Actual change in employment is close to zero; this statistic cannot be calculated.

Source: National Science Foundation

other science resources publications

Science Resources Studies Highlights

	NSF No.	Price
R&D Funds		
"Significant Increase Expected in Industrial R&D Performance of Federal R&D Programs in FY 1983"	82-329	-----
"Growth in Federal Basic Research Support in 1980-83 Moves at Slower Rate than in Previous Four Years"	82-325	-----
"Companies Plan R&D Expenditure Increases for 1983: Growth Rate Down"	82-324	-----
"Defense Leads R&D Growth in FY 1983—Energy and Natural Resources and Environment Fall Sharply"	82-322	-----
"Universities Spent 6% of Separately Budgeted R&D Expenditures for Research Equipment in 1980"	82-316	-----
"National R&D Expenditures Expected to Reach $85 Billion in 1983"	82-311	-----
S/E Personnel		
"Growth in Employment of Science and Engineering Doctorates Continues, Led by Computer Scientists"	82-328	-----
"Science/Engineering Doctorate Production Increases in 1981, More New Doctorates Seek Nonacademic Positions"	82-323	-----
"Employment of Recent Science and Engineering (S/E) Graduates in S/E Fields Increased"	82-320	-----
"Academic Science/Engineering Employment Increased 3% Between 1980 and 1981"	82-312	-----

Detailed Statistical Tables

	NSF No.	Price
R&D Funds		
Federal Funds for Research and Development, Fiscal Years 1981, 1982, and 1983, Volume XXXI	82-326	-----
Research and Development in Industry, 1980. Funds, 1980; Scientists and Engineers, January 1981	82-317	-----
Academic Science: R&D Funds, Fiscal Year 1980	82-300	-----
S/E Personnel		
Characteristics of Doctoral Scientists and Engineers in the United States: 1981	82-332	-----
U.S. Scientists and Engineers: 1980	82-314	-----
Characteristics of Recent Science/Engineering Graduates: 1980	82-313	-----
Academic Science: Scientists and Engineers, January 1981	82-305	-----
Academic Science: Graduate Enrollment and Support, Fall 1980	81-330	-----
Federal Scientific and Technical Personnel: 1976, 1977, and 1978	81-309	-----

Reports

	NSF No.	Price
R&D Funds		
Federal Funds for Research and Development, Fiscal Years 1980, 1981, and 1982, Volume XXX	82-321	$4.75
1990 R&D Funding Projections	82-315	$3.50
Federal Support to Universities, Colleges, and Selected Nonprofit Institutions, Fiscal Year 1980	82-308	$6.50
Problems of Small, High-Technology Firms	81-305	-----
S/E Personnel		
Science and Engineering Degrees: 1950-80, A Source Book	82-307	$5.00
Women and Minorities in Science and Engineering	82-302	$7.00
Activities of Science and Engineering Faculty in Universities and 4-Year Colleges, 1978/79	81-323	-----
Young and Senior Science and Engineering Faculty, 1980	81-319	-----
Foreign Participation in U.S. Science and Engineering Higher Education and Labor Markets	81-316	$4.50
Science and Engineering Employment: 1970-80	81-310	$2.75
The Stock of Science and Engineering Master's Degree-Holders in the United States	81-302	-----
Composite		
National Patterns of Science and Technology Resources, 1982	82-319	$5.00
Science and Engineering Personnel: A National Overview	82-318	$5.00
Academic Science: 1972-81, R&D Funds, Scientists and Engineers, Graduate Enrollment and Support	81-326	-----